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- (71) Applicant(s)
CSL Limited
- (72) Inventor(s)
An, Zhiqiang;Zaller, Dennis;Nash, Andrew Donald;Strohl, William R.;Baca, Manuel;Fabri, Louis Jerry
- (74) Agent / Attorney
FB Rice & Co, Level 23 200 Queen Street, Melbourne, VIC, 3000
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(74) Agents: LICATA, Jane, Massey et al.; Licata & Tyrrell
P.C., 66 E. Main Street, Marlton, NJ 08053 (US).

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(71) Applicants (for all designated States except US): **MERCK
& CO., INC.** [US/US]; 126 E. Lincoln Avenue, Rahway,
NJ 07065-0907 (US). **CSL LIMITED** [AU/AU]; 45
Poplar Road, Parkville, Victoria 3052 (AU).

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(72) Inventors; and

(75) Inventors/Applicants (for US only): **NASH, Andrew,
Donald** [AU/AU]; 185 Peel Street, Kew, Victoria 3084
(AU). **BACA, Manuel** [AU/US]; 720 Market Street East,
Gaithersburg, MD 20878 (US). **FABRI, Louis, Jerry**
[AU/AU]; 41 Phipps Crescent, Diamond Creek, Victoria
3089 (AU). **ZALLER, Dennis** [US/US]; 807 Raritan
Road, Scotch Plains, NJ 07076 (US). **STROHL, William,
R.** [US/US]; 1086 Tullo Farm Road, Bridgewater, NJ
08807 (US). **AN, Zhiqiang** [US/US]; 315 Gentry Lane,
Ambler, PA 19002 (US).

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(54) Title: HIGH AFFINITY ANTIBODY ANTAGONISTS OF INTERLEUKIN-13 RECEPTOR ALPHA 1

(57) Abstract: High affinity antibody antagonists of human interleukin-13 receptor alpha 1 are disclosed. The antibody molecules are effective in the inhibition of IL-13R α 1-mediated activities and, accordingly, present desirable antagonists for the use in the treatment of conditions associated with hIL-13R α 1 activity. The present invention also discloses nucleic acid encoding said antibody molecules, vectors, host cells, and compositions comprising the antibody molecules. Methods of using the antibody molecules for inhibiting or antagonizing IL-13R α 1-mediated activities are also disclosed.



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HIGH AFFINITY ANTIBODY ANTAGONISTS OF INTERLEUKIN-13 RECEPTOR ALPHA 1

Introduction

5 This application claims benefit of priority to U.S. Provisional Patent Application Serial No. 60/852,884, filed October 19, 2006, the content of which is incorporated herein by reference in its entirety.

10 Background of the Invention

 Data from human studies and experimental animal models strongly implicate Th2-derived cytokines as contributing to atopic asthma, with interleukin-4 (IL-4) and interleukin-13 (IL-13; see, e.g., Minty et al., 1993 *Nature* 362:248-250; 15 McKenzie et al., 1993 *Proc. Natl. Acad. Sci. USA* 90:3735-3739; Acc. Nos: U31120 and L13029 (human) and NM_001032929 (*Macaca mulatta*)) playing the most central role. These two cytokines have significant structural similarities and share certain receptor components. The receptor that IL-4 and IL-20 13 share is a dual IL-4R/IL-13 receptor (or type II receptor) which binds both IL-4 and IL-13. This receptor is composed of the IL-4R α chain (see, e.g., Idzerda et al., 1990 *J. Exp. Med.* 171:861-873) and the IL-13R α 1 chain (see, e.g., Hilton et al., 1996 *Proc. Natl. Acad. Sci. USA* 93:497-25 501; Aman et al., 1996 *J. Biol. Chem.* 271:29265-29270; Miloux et al., 1997 *FEBS Lett.* 401:163-166; Acc. Nos: U62858 and CAA70508 (human) and AAP78901 (*Macaca fascicularis*)). The dual IL-4R/IL-13R receptor is expressed on hematopoietic and non-hematopoietic cells, including lung epithelial and 30 smooth muscle cells. Both IL-4 and IL-13, additionally, each have one receptor that recognizes them to the exclusion of the other. For instance, IL-4 receptor (IL-4R) type I, composed of the IL-4R α chain and the common gamma chain (γ c), specifically binds IL-4. IL-4R type I is expressed 35 exclusively on cells of hematopoietic origin. The receptor

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specific for IL-13, IL-13R α 2, binds IL-13 with high affinity, but apparently does not transduce signals. Rather, the receptor acts as a decoy to attenuate the response to IL-13.

5 IL-13 and IL-4 carry out a number of functions and both regulate a number of functions related to the allergic phenotype, such as isotype class switching to IgE in B-cells, activation of mast cells and eosinophils, up-regulation of vascular cell adhesion molecule-1 (VCAM-1) on
10 endothelial cells, and production of chemokines such as eotaxins, thymus and activation-regulated chemokine (TARC), and macrophage-derived chemokine (MDC).

IL-4 and IL-13, though, have many distinct functions *in vitro* and *in vivo* owing to differences in their receptor
15 complexes. For instance, sequestration of IL-13, but not IL-4, has been shown to prevent airway hyperreactivity and reduce mucous production in mouse asthma models. This correlation between IL-13 and the asthmatic response has been further supported by other studies; see, e.g., Hershey
20 *et al.*, 2003 *J. Allergy Clin. Immunol.* 111(4):677-690; Grunig *et al.*, 1998 *Science* 282(5397):2261-2263; Mattes *et al.*, 2001 *J. Immunol.* 167(3):1683-1692; and Fulkerson *et al.*, 2006 *Am. J. Respir. Cell. Mol. Biol.* 35(3):337-346. Delivery of IL-13 to the lung, for example, has been found
25 to be sufficient to induce the entire asthma-like phenotype in mice. Treated animals develop airway hyperreactivity, eosinophil-rich cell inflammation, goblet cell hyperplasia with associated mucous overproduction, and subepithelial fibrosis; see, e.g., Wills-Karp *et al.*, 1998 *Science*
30 282(5397): 2258-2261; Reiman *et al.*, 2006 *Infect. Immun.* 74(3): 1471-1479; and Kaviratne *et al.*, 2004 *J. Immunol.* 173(6):4020-4029. Expression of IL-13 has, furthermore, been reported to be elevated in the lungs of human asthma. To

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polymorphisms in the IL-13 gene with an increased risk of allergic traits and asthma symptoms. Some of these polymorphisms have been shown to be correlated with increased expression of IL-13; see, e.g., Huang et al., 1995
5 *J. Immunol.* 155(5):2688-2694; Naseer et al., 1997 *Am. J. Respir. Crit. Care Med.* 155(3):845-851; Vladich et al., 2005 *J. Clin. Invest.* 115(3):747-754; Chen et al., 2004 *J. Allergy Clin. Immunol.* 114(3):553-560; and Vercelli et al., 2002 *Curr. Opin. Allergy Clin. Immunol.* 2(5):389-393.

10 IL-13 has also been associated with various other conditions, including but not limited to various respiratory and allergy-mediated disorders, fibrosis, scleroderma, inflammatory bowel disease and certain cancers; see, e.g., Wynn, T.A., 2003 *Annu. Rev. Immunol.* 21:425-456; Terabe et al., 2000 *Nat. Immunol.* 1(6):515-520; Fuss et al., 2004 *J. Clin. Invest.* 113(10):1490-1497; Simms et al., 2002 *Curr. Opin. Rheumatol.* 14(6):717-722; and Hasegawa et al., 1997 *J. Rheumatol.* 24(2):328-332.

An antagonist of IL-13 would, therefore, be a highly
20 attractive molecule for use in the development of a treatment for IL-13-associated disorders. An effective antibody antagonist would interfere with the binding of IL-13 to IL-13R. An effective antibody antagonist to IL-13R α 1 may also interfere with the binding of IL-13 and prevent
25 heterodimerization of IL-4R α and IL-13R α 1. Such an antibody could inhibit signaling of both IL-13 and IL-4 through the type II receptor while sparing IL-4 signaling through the type I receptor. Signaling through the type I receptor is essential in the induction phase of the immune response
30 during which Th2 cells differentiate. T cells do not express IL-13R α 1 so the type II receptor plays no role in Th2 differentiation. Hence, an IL-13R α 1 antibody should not affect the overall Th1/Th2 balance. Signaling through the type II IL-4/IL-13 receptor is critical during the effector

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stage of the immune response during established allergic inflammation. Thus, blockade of the type II receptor should have a beneficial effect on many of the symptoms of asthma and other IL-13R-mediated conditions and should, therefore,
5 be an effective disease modifying agent.

Antibodies against IL-13R α 1 (both monoclonal and polyclonal) have been described in the art; see, e.g., WO 97/15663, WO 03/80675; WO 03/46009; WO 06/072564; Gauchat et al., 1998 *Eur. J. Immunol.* 28:4286-4298; Gauchat et al.,
10 2000 *Eur. J. Immunol.* 30:3157-3164; Clement et al., 1997 *Cytokine* 9(11):959 (Meeting Abstract); Ogata et al., 1998 *J. Biol. Chem.* 273:9864-9871; Graber et al., 1998 *Eur. J. Immunol.* 28:4286-4298; C. Vermot-Desroches et al., 2000 *Tissue Antigens* 5(Supp. 1):52-53 (Meeting Abstract);
15 Poudrier et al., 2000 *Eur. J. Immunol.* 30:3157-3164; Akaiwa et al., 2001 *Cytokine* 13:75-84; Cancino-Díaz et al., 2002 *J. Invest. Dermatol.* 119:1114-1120; and Krause et al., 2006 *Mol. Immunol.* 43:1799-1807.

There is a need for an antibody with enhanced
20 biological activity that could impact activities associated with the allergy and asthmatic response as well as other various conditions that have been attributed at least in part to an increased expression/functioning of IL-13R α 1. There is further a need for an antibody molecule with high
25 affinity for IL-13R α 1 with low immunogenicity in humans. Accordingly, it would be of great import to produce a therapeutic-based human antibody antagonist of IL-13R α 1 that inhibits or antagonizes the activity of IL-13R α 1 and the corresponding role IL-13R α 1 plays in various therapeutic
30 conditions.

Summary of the Invention

The present invention relates to high affinity antibody antagonists of IL-13R α 1 and particularly human IL-13R α 1.

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Disclosed antibody molecules selectively recognize IL-13R α 1, particularly human IL-13R α 1, exhibiting binding to human IL-13R α 1 with a K_D of 5×10^{-9} or less, more preferably 2×10^{-9} or less, and even more preferably, 1×10^{-9} or less.

5 Specific antibody molecules in accordance herewith additionally, bind primate IL-13R α 1 with high affinity, a desirable quality given the accessibility of non-human primate models for predicting efficacy and safety profiles in humans. Antibody molecules in accordance herewith are

10 effective in the inhibition of IL-13R α 1-mediated activities and, thus, are of import in the treatment of conditions associated therewith, including, but not limited to, asthma, allergy, allergic rhinitis, chronic sinusitis, hay fever, atopic dermatitis, chronic obstructive pulmonary disease

15 ("COPD"), pulmonary fibrosis, esophageal eosinophilia, scleroderma, psoriasis, psoriatic arthritis, fibrosis, inflammatory bowel disease (particularly, ulcerative colitis), anaphylaxis, and cancer (particularly, Hodgkin's lymphoma, glioma, and renal carcinoma), and general Th2-

20 mediated disorders/conditions. IL-13R α 1-specific antibodies also have utility for various diagnostic purposes in the detection and quantification of IL-13R α 1.

The present invention provides, in one particular aspect, the isolated antibody, 10G5, which very effectively

25 antagonizes IL-13 functioning through IL-13R α 1. 10G5 exhibits inhibition of IL-13- and IL-4-induced eotaxin release in NHDF cells, IL-13- and IL-4-induced STAT6 phosphorylation in NHDF cells, and IL-13-stimulated release of TARC in blood or peripheral blood mononuclear cells

30 (PBMCs). The present invention, thus, encompasses antibodies as produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933. The present invention also encompasses antibodies that compete for binding to hIL-13R α 1 with an

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antibody of PTA-6933. Particular embodiments of the present invention include antibody molecules including heavy and/or light chain variable region sequences of 10G5, as well as equivalents (characterized as having one or more conservative amino acid substitutions) or homologs thereof. Particular embodiments embrace isolated antibody molecules that have the CDR domains disclosed herein or sets of heavy and/or light chain CDR domains disclosed herein, or equivalents thereof, characterized as having one or more conservative amino acid substitutions. Specifically, antibody molecules of the invention have a heavy chain variable region with CDR1, CDR2, and CDR3 amino acid sequences as set forth in SEQ ID NO:82, SEQ ID NO:83, and SEQ ID NO:121, respectively; and a light chain variable region with CDR1, CDR2, and CDR3 amino acid sequences as set forth in SEQ ID NO:84, SEQ ID NO:85, and SEQ ID NO:122. More particularly, antibody molecules of the invention have a heavy chain variable region with an amino acid sequence as set forth in SEQ ID NO:45, SEQ ID NO:51, SEQ ID NO: 55, SEQ ID NO:59, SEQ ID NO:63 or SEQ ID NO:67; a light chain variable region with an amino acids sequence as set forth in SEQ ID NO:49, SEQ ID NO:71, SEQ ID NO:75 or SEQ ID NO:79; or a combination of the above-referenced heavy chain and light chain variable regions.

As will be appreciated by those skilled in the art, fragments of an antibody that retain the ability to bind to hIL-13R α 1 may be inserted into various frameworks, see, e.g., U.S. Patent No. 6,818,418, and references contained therein, which discuss various scaffolds which may be used to display antibody loops previously selected on the basis of antigen binding. In addition, genes encoding for V_L and V_H can be joined, using recombinant methods, for example using a synthetic linker that enables them to be made as a single protein chain in which the V_L and V_H regions pair to form

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monovalent molecules, otherwise known as single chain Fvs (ScFVs); see, e.g., Bird et al., 1988 *Science* 242: 423-426, and Huston et al., 1988 *Proc. Natl. Acad. Sci. USA* 85:5879-5883.

5 In another aspect, the present invention provides nucleic acid encoding the disclosed antibody molecules. The present invention also provides nucleic acids encoding the variable heavy and light chains and select components thereof, particularly the disclosed respective CDR3 regions.

10 In another aspect, the present invention provides vectors including said nucleic acid. In another aspect, the present invention provides isolated cell(s) harboring nucleic acid encoding the disclosed antibody molecules and components thereof as described. In another aspect, the present

15 invention provides isolated cell(s) comprising a polypeptide or vector of the present invention.

In another aspect, the present invention provides a method of making an antibody molecule which selectively binds IL-13R α 1 (inclusive of antibodies, antigen binding

20 fragments, derivatives, chimeric molecules, fusions of any of the foregoing with another polypeptide, or alternative structures/compositions incorporating any of the foregoing) of the present invention, which includes incubating a cell harboring nucleic acid encoding a heavy and/or a light chain

25 (depending on the antibody molecule being produced) under conditions that allow for the expression and/or assembly of said heavy and/or light chains into the antibody molecule, and isolating said antibody molecule from the cell. One of skill in the art can obtain the antibody molecules disclosed

30 herein using standard recombinant DNA techniques.

In another aspect, the present invention provides a method for antagonizing the activity or function of IL-13R α 1, be it signaling or other, which includes contacting a cell expressing IL-13R α 1 with an antibody molecule disclosed

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herein under conditions that allow said antibody molecule to bind to IL-13R α 1. Specific embodiments of the present invention include such methods wherein the cell is a human cell. Antibody molecules in accordance herewith are effective in the inhibition of IL-13R α 1-mediated activities. Antibody molecules in accordance with the present invention were found to effectively inhibit eotaxin release from normal human dermal fibroblast cells (hereinafter "NHDF" cells). Antibody molecules in accordance with the present invention were found to effectively inhibit IL-13- and IL-4-stimulated STAT6 phosphorylation in NHDF cells and found to effectively inhibit the IL-13-stimulated release of TARC (CCL17) in whole blood (human/rhesus).

In another aspect, the present invention provides a method of antagonizing the activity of IL-13R α 1 in a subject exhibiting a condition associated with IL-13R α 1 activity (or a condition where the functioning of IL-13R α 1 is deemed not beneficial to the particular subject), which involves administering to the subject a therapeutically effective amount of an antibody molecule of the present invention. In select embodiments, the condition may be asthma, allergy, allergic rhinitis, chronic sinusitis, hay fever, atopic dermatitis, chronic obstructive pulmonary disease ("COPD"), pulmonary fibrosis, esophageal eosinophilia, psoriasis, psoriatic arthritis, fibrosis, scleroderma, inflammatory bowel disease (particularly, ulcerative colitis), anaphylaxis, and cancer (particularly, Hodgkin's lymphoma, glioma, and renal carcinoma), and general Th2-mediated disorders/conditions. In another aspect, the present invention provides a pharmaceutical composition or other composition including an antibody molecule of the invention (or alternative antigen-binding structure or protein that comprises an IL-13R α 1-specific antigen binding portion disclosed herein) and a pharmaceutically acceptable carrier,

excipient, diluent, stabilizer, buffer, or alternative designed to facilitate administration of the antibody molecule in the desired amount to the treated individual.

Another aspect of the present invention concerns the identification of a critical contact point between the antibodies disclosed herein and hIL-13R α 1. This critical
5 contact point was identified by the generation of a specific mutation that impacted the binding of the receptor by the antibody. More specifically, it was found that substitution of the phenylalanine residue at position 233 of SEQ ID NO:101 with an alanine residue results in a loss of binding between the antibody and the receptor. This is a very useful finding in characterizing 10G5 and its derivatives. Peptides exploiting
10 the narrow region surrounding amino acid 233 will be useful in the generation of additional monoclonal antibodies with similar specificity. Accordingly, the present invention encompasses isolated peptides including hIL-13R sequence with a Phe233Ala mutation, whether they be full-length or fragments thereof including the mutation. Additionally, the present invention also encompasses the use of said peptides
15 in an assay to evaluate 10G5 or 10G5 derivatives, identify antibodies with specificity for a similar epitope or, alternatively, produce antibodies with similar specificity.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of
20 any other element, integer or step, or group of elements, integers or steps.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the
25 field relevant to the present invention as it existed before the priority date of each claim of this application.

Brief Description of the Drawings

Figure 1 illustrates the nucleotide and derived amino acid sequence of the heavy
30 chain variable region of antibody 10G5. CDRs and nucleic acid encoding CDRs are underlined.

Figure 2 illustrates the nucleotide and derived amino acid sequence of the light chain variable region of antibody 10G5. CDRs and nucleic acid encoding CDRs are underlined.

35 Figure 3 illustrates a genetic map of pFab3d.

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Figures 4A and 4B illustrate heavy and light chain constructs, SEQ ID NOs:86 AND 87, respectively, of 10G5 Fab in pFab3d.

Figure 5 illustrates binding of mutated Fabs from periplasmic preparations to rhesus IL-13R α 1.

Figure 6 illustrates ELISA analysis of binding of periplasmic preparations of 10G5 mutants to human IL-13R α 1.

Figure 7 illustrates ELISA analysis of binding of periplasmic preparations of 10G5 mutants to human IL-13R α 1.

Figure 8 illustrates Myc-capture ELISA data for light chain variant clones.

Figure 9 illustrates the functioning of 10G5, 10G5H6, and 10G5-6 in a NHDF eotaxin release assay.

Figure 10 illustrates the functioning of 10G5-6 in blocking IL-13- and IL-4-stimulated eotaxin release in NHDF cells.

Figure 11 illustrates the functioning of 10G5 and 10G5H6 in an IL-13-induced STAT6 assay.

Figure 12 illustrates the functioning of 10G5 and 10G5H6 in an IL-4-induced STAT6 assay.

Figure 13 illustrates the functioning of 10G5-6 in blocking IL-13-stimulated release of TARC (CCL17) in whole human blood.

Figure 14 illustrates the functioning of 10G5 and 10G5H6 in an IL-13-stimulated TARC release assay in whole human blood.

Figure 15 illustrates the functioning of 10G5H6 and 10G5-6 in blocking rhesus IL-13-stimulated release of TARC in whole rhesus blood.

Figure 16 illustrates a sequence comparison of the Fc domains of IgG1 (SEQ ID NO:97), IgG2 (SEQ ID NO:98), IgG4 (SEQ ID NO:99) and the IgG2m4 (SEQ ID NO:100) isotypes.

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Figure 17 illustrates inhibition of cell proliferation of Hodgkin's Disease cell line L1236 by 10G5, 10G5H6, and 10G5-6.

5 Detailed Description of the Invention

The present invention relates to high affinity antibody antagonists of IL-13R α 1 and particularly human IL-13R α 1. Disclosed antibody molecules selectively recognize and specifically bind to IL-13R α 1. In particular embodiments, 10 the antibodies bind primate IL-13R α 1 (e.g., cynomolgus IL-13R α 1) with high affinity, a desirable quality given the accessibility of non-human primate models for predicting efficacy and safety profiles in humans. Use of the terms "selective" or "specific" herein refers to the fact that the 15 disclosed antibody molecules do not show significant binding to other than IL-13R α 1. The disclosed antibody molecules bind to human IL-13R α 1 with a K_D of 5×10^{-9} or less, more preferably 2×10^{-9} or less, and even more preferably, 1×10^{-9} or less. K_D refers to the dissociation constant obtained 20 from the ratio of K_d (the dissociation rate of a particular antibody-antigen interaction) to K_a (the association rate of the particular antibody-antigen interaction), or K_d/K_a which is expressed as a molar concentration (M). K_D values can be determined using methods well established in the art. A 25 preferred method for determining the K_D of an antibody is by using surface plasmon resonance, for example a biosensor system such as a BIACORE™ (Pharmacia AB Corporation) system.

Antibodies, as described herein, are particularly effective in antagonizing IL-13R α 1 function, or IL-13R α 1-mediated activity as referred to herein. The language "IL-13R α 1-mediated" activity/function is used herein to refer to 30 any activity/function that requires, or is exacerbated or enhanced by, the function of IL-13R α 1. The disclosed

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antibody molecules have been shown to exhibit at least one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; or (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs. Specific embodiments of the present invention provide antibody molecules that antagonize IL-13 α 1-mediated eotaxin release from NHDF cells with an IC₅₀ of 1.0 μ g/ml or less, more preferably, 0.5 μ g/ml or less, and more preferably yet, 0.1 μ g/ml or less. Specific embodiments of the present invention provide antibody molecules that antagonize IL-13 α 1-mediated STAT6 phosphorylation in NHDF cells. Specific embodiments of the present invention provide antibody molecules that antagonize IL-13 α 1-mediated TARC (CCL17) release in whole blood or PBMCs with an IC₅₀ of 1000 ng/ml or less, more preferably, 500 ng/ml or less, and more preferably yet, 250 ng/ml or less. The extent of antagonism by any particular antibody can be measured quantitatively as the IC₅₀ value in statistical comparison to a control, or via any alternative method available in the art for assessing a negative effect on, or inhibition of, IL-13 α 1 function (*i.e.*, any method capable of assessing antagonism of IL-13 α 1 function).

"Antibody molecule" or "antibody", as described herein, refers to an immunoglobulin-derived structure with selective binding to hIL-13 α 1 including, but not limited to, a full length or whole antibody, an antigen binding fragment (a fragment derived, physically or conceptually, from an antibody structure), a derivative of any of the foregoing, a chimeric molecule, a fusion of any of the foregoing with another polypeptide, or any alternative

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structure/composition which incorporates any of the foregoing for purposes of selectively binding/inhibiting the function of IL-13R α 1. "Whole" antibodies or "full-length" antibodies refer to proteins that have two heavy (H) and two
5 light (L) chains inter-connected by disulfide bonds which include: (1) in terms of the heavy chains, a variable region (abbreviated herein as "V_H") and a heavy chain constant region which has three domains, C_{H1}, C_{H2}, and C_{H3}; and (2) in terms of the light chains, a light chain variable region
10 (abbreviated herein as "V_L") and a light chain constant region which includes one domain, C_L. "Isolated", as used herein, describes a property as it pertains to the disclosed antibody molecules, nucleic acid or other that makes them different from that found in nature. The difference can be,
15 for example, that they are of a different purity than that found in nature, or that they are of a different structure or form than that found in nature. A structure not found in nature, for example, includes recombinant human immunoglobulin structures including, but not limited to,
20 recombinant human immunoglobulin structures with optimized complementarity determining regions (CDRs). Other examples of structures not found in nature are antibody molecules or nucleic acid substantially free of other cellular material. Isolated antibodies are generally free of other antibodies
25 having different antigenic specificities (other than IL-13R α 1).

Antibody fragments and, more specifically, antigen binding fragments are molecules possessing an antibody variable region or segment thereof (which includes one or
30 more of the disclosed CDR 3 domains, heavy and/or light), which confers selective binding to IL-13R α 1, and particularly human IL-13R α 1 (hIL-13R α 1). Antibody fragments containing such an antibody variable region include, but are not limited to the following antibody molecules: a Fab, a

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F(ab')₂, a Fd, a Fv, a scFv, bispecific antibody molecules (i.e., antibody molecules including an IL-13R α 1-specific antibody or antigen binding fragment as disclosed herein linked to a second functional moiety having a different binding specificity than the antibody, including, without limitation, another peptide or protein such as an antibody, or receptor ligand), a bispecific single chain Fv dimer, an isolated CDR3, a minibody, a 'scAb', a dAb fragment, a diabody, a triabody, a tetrabody, and artificial antibodies based upon protein scaffolds, including but not limited to fibronectin type III polypeptide antibodies (see, e.g., U.S. Patent No. 6,703,199, WO 02/32925 and WO 00/34784) or cytochrome B (see, e.g., Nygren et al., 1997 *Curr. Opin. Struct. Biol.* 7:463-469). The antibody portions or binding fragments may be natural, or partly or wholly synthetically produced. Such antibody portions can be prepared by various means known by one of skill in the art, including, but not limited to, conventional techniques, such as papain or pepsin digestion.

The present invention provides, in one particular aspect, isolated antibody 10G5 which very effectively antagonizes IL-13 functioning through IL-13R α 1. 10G5 has exhibited inhibition of IL-13- and IL-4-induced eotaxin release in NHDF cells, IL-13- and IL-4-induced STAT6 phosphorylation in NHDF cells, and IL-13-stimulated release of TARC in blood or peripheral blood mononuclear cells (PBMCs). The present invention, thus, encompasses antibodies as produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933. The present invention also encompasses antibody molecules that compete for binding to hIL-13R α 1 with an antibody of PTA-6933. Additional embodiments of the present invention are antibody molecules that compete for binding to hIL-13R α 1 with antibodies disclosed herein. Specific embodiments of the present invention provide

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isolated antibody molecules which inhibit the binding of IL-13 to hIL-13R α 1.

Particular embodiments of the present invention include antibody molecules having heavy and/or light chain variable region sequences of 10G5, as well as equivalents (characterized as having one or more conservative amino acid substitutions) or homologs thereof. Particular embodiments are isolated antibody molecules that include the CDR domains disclosed herein or sets of heavy and/or light chain CDR domains disclosed herein, or equivalents thereof, characterized as having one or more conservative amino acid substitutions. Use of the terms "domain" or "region" herein simply refers to the respective portion of the antibody molecule wherein the sequence or segment at issue will reside or, in the alternative, currently resides.

Table 1 provides a generalized outline of sequences embraced by the present invention.

TABLE 1

SEQ ID NO:	DESCRIPTION
SEQ ID NO:1	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:2	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:3	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:4	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:5	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:6	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:7	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:8	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:9	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:10	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:11	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:12	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:13	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:14	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:15	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:16	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:17	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:18	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:19	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:20	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:21	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:22	VARIANT SEQUENCE W/ OPTIMIZED CDR3

SEQ ID NO:23	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:24	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:25	VARIANT SEQUENCE W/ OPTIMIZED CDR3
SEQ ID NO:26	HEAVY CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:27	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:28	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:29	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:30	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:31	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:32	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:33	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:34	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:35	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:36	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:37	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:38	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:39	LIGHT CHAIN CDR3 OPTIMIZED VARIANT
SEQ ID NO:40	10G5 HEAVY CHAIN CDR3
SEQ ID NO:41	10G5 LIGHT CHAIN CDR3
SEQ ID NO:42	10G5 VH SEQ W/ LEADER, & ADDITIONAL CONSTANT REGION - NUCLEIC ACID
SEQ ID NO:43	10G5 VH SEQUENCE ONLY - NUCLEIC ACID
SEQ ID NO:44	10G5 VH SEQ W/ LEADER, & ADDITIONAL CONSTANT REGION - PROTEIN
SEQ ID NO:45	10G5 VH SEQUENCE ONLY - PROTEIN
SEQ ID NO:46	10G5 VL SEQ W/ LEADER & ADDITIONAL CONSTANT REGION - NUCLEIC ACID
SEQ ID NO:47	10G5 VL SEQUENCE ONLY - NUCLEIC ACID
SEQ ID NO:48	10G5 VL SEQ W/ LEADER & ADDITIONAL CONSTANT REGION - PROTEIN
SEQ ID NO:49	10G5 VL SEQUENCE ONLY - PROTEIN
SEQ ID NO:50	10G5-1,3 HEAVY CHAIN*
SEQ ID NO:51	10G5-1,3 VH*
SEQ ID NO:52	10G5-1,3 HEAVY CHAIN NUCLEIC ACID*
SEQ ID NO:53	10G5-1,3 VH NUCLEIC ACID*
SEQ ID NO:54	10G5-2 HEAVY CHAIN
SEQ ID NO:55	10G5-2 VH
SEQ ID NO:56	10G5-2 HEAVY CHAIN NUCLEIC ACID
SEQ ID NO:57	10G5-2 VH NUCLEIC ACID
SEQ ID NO:58	10G5-4,5 HEAVY CHAIN*
SEQ ID NO:59	10G5-4,5 VH*
SEQ ID NO:60	10G5-4,5 HEAVY CHAIN NUCLEIC ACID*
SEQ ID NO:61	10G5-4,5 VH NUCLEIC ACID*
SEQ ID NO:62	10G5-6, HEAVY CHAIN*
SEQ ID NO:63	10G5-6, VH*
SEQ ID NO:64	10G5-6, HEAVY CHAIN NUCLEIC ACID*
SEQ ID NO:65	10G5-6, VH NUCLEIC ACID*
SEQ ID NO:66	10G5-7, 8 HEAVY CHAIN
SEQ ID NO:67	10G5-7, 8 VH

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SEQ ID NO:68	10G5-7, 8 HEAVY CHAIN NUCLEIC ACID
SEQ ID NO:69	10G5-7, 8 VH NUCLEIC ACID
SEQ ID NO:70	10G5-1,2,4,6,7 LIGHT CHAIN*
SEQ ID NO:71	10G5-1,2,4,6,7 VL*
SEQ ID NO:72	10G5-1,2,4,6,7 LIGHT CHAIN NUCLEIC ACID*
SEQ ID NO:73	10G5-1,2,4,6,7 VL NUCLEIC ACID*
SEQ ID NO:74	10G5-3 LIGHT CHAIN
SEQ ID NO:75	10G5-3 VL
SEQ ID NO:76	10G5-3 LIGHT CHAIN NUCLEIC ACID
SEQ ID NO:77	10G5-3 VL NUCLEIC ACID
SEQ ID NO:78	10G5-5,8 LIGHT CHAIN*
SEQ ID NO:79	10G5-5,8 VL*
SEQ ID NO:80	10G5-5,8 LIGHT CHAIN NUCLEIC ACID*
SEQ ID NO:81	10G5-5,8 VL NUCLEIC ACID*
SEQ ID NO:82	10G5 VH CDR1
SEQ ID NO:83	10G5 VH CDR2
SEQ ID NO:84	10G5 VL CDR1
SEQ ID NO:85	10G5 VL CDR2
SEQ ID NO:86	PFAB3D-10G5H
SEQ ID NO:87	PFAB3D-10G5L
SEQ ID NO:92	CONSTANT OF IGG2M4
SEQ ID NO:93	CONSTANT OF IGG2M4 NUCLEIC ACID
SEQ ID NO:94	10G5-6 HEAVY CHAIN IGG2M4
SEQ ID NO:95	10G5-6 HEAVY CHAIN IGG2M4 NUCLEIC ACID
SEQ ID NO:96	10G5H6 HEAVY CHAIN IGG2M4
SEQ ID NO:97	IGG1 FC
SEQ ID NO:98	IGG2 FC
SEQ ID NO:99	IGG4 FC
SEQ ID NO:100	IGG2M4 FC
SEQ ID NO:101	Mature human IL-13 receptor $\alpha 1$
SEQ ID NO:103	hIL-13R $\alpha 1$.ECR
SEQ ID NO:104	Mature cynomolgus IL-13R $\alpha 1$ sequence
SEQ ID NO:105	Mature murine IL-13R $\alpha 1$ sequence
SEQ ID NO:106	VH CDR1 NUCLEIC ACID
SEQ ID NO:107	VH CDR2 NUCLEIC ACID
SEQ ID NO:108	VH CDR3 NUCLEIC ACID
SEQ ID NO:109	VL CDR1 NUCLEIC ACID
SEQ ID NO:110	VL CDR2 NUCLEIC ACID
SEQ ID NO:111	VL CDR3 NUCLEIC ACID
SEQ ID NO:112	VH CDR3 10G5-6 NUCLEIC ACID
SEQ ID NO:113	VL CDR3 10G5-6 NUCLEIC ACID
SEQ ID NO:120	Mutant human IL-13 receptor $\alpha 1$
SEQ ID NO:121	VH CDR3
SEQ ID NO:122	VL CDR3
SEQ ID NO:123	VL CDR1 NUCLEIC ACID

*Note: Where a particular SEQ ID NO: is relevant to more than one designated antibody, the following format may be utilized as an abbreviation of the different antibodies:

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Antibody Base Designation-One Assigned No., Another Assigned No., etc. An example of this is as follows: 10G5-1,3 refers to both 10G5-1 and 10G5-3.

5 In specific embodiments, the present invention provides isolated antibody molecules including a heavy chain variable region of SEQ ID NO:45, equivalents thereof characterized as having one or more conservative amino acid substitutions, and homologs thereof. The disclosed antibodies exhibit at
10 least one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-
15 induced STAT6 phosphorylation in NHDF cells; or (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs. In specific embodiments, the present invention provides homologs of the disclosed antibody molecules characterized as being at least 90% homologous thereto and
20 exhibiting at least one of the above functional properties. Specific antibodies provided will compete for binding to hIL-13R α 1 with an antibody as produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933.

In specific embodiments, the present invention provides
25 isolated antibody molecules including a light chain variable region of SEQ ID NO:49, equivalents thereof characterized as having one or more conservative amino acid substitutions, and homologs thereof. The disclosed antibodies exhibit at least one of the following functional properties: (i)
30 inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-
induced STAT6 phosphorylation in NHDF cells; and (v)
35 inhibition of IL-13-stimulated release of TARC in blood or PBMCs. In specific embodiments, the present invention

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provides homologs of the disclosed antibody molecules characterized as being at least 90% homologous thereto and exhibiting at least one of the above functional properties. Specific antibodies provided will compete for binding to
5 hIL-13R α 1 with an antibody as produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933.

In specific embodiments, the present invention provides isolated antibody molecules which comprise a heavy chain variable region comprising SEQ ID NO:45 and light chain
10 variable region comprising SEQ ID NO:49; or equivalent thereof characterized as having one or more conservative amino acid substitutions. Specific embodiments are said antibodies which exhibit at least one of the following functional properties: (i) inhibition of IL-13-induced
15 eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; and (v) inhibition of IL-13-stimulated release of
20 TARC in blood or PBMCs.

In particular embodiments, the present invention provides isolated IL-13R α 1 antibody molecules that include the variable heavy CDR3 sequence, SEQ ID NO:40, and conservative modifications thereof, which exhibit at least
25 one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6
30 phosphorylation in NHDF cells; and (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs. Heavy chain variable region CDR3 sequences particularly embraced by the present invention are listed in Table 2.

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TABLE 2

SEQ ID NO:	V _H CDR3 Sequence
SEQ ID NO: 1	FPNWGALDQ
SEQ ID NO: 2	VPNWGSLDT
SEQ ID NO: 3	FPNWGSMDA
SEQ ID NO: 4	FPNWGSLDH
SEQ ID NO: 5	MPNWGSFDY
SEQ ID NO: 6	MPNWGSFDT
SEQ ID NO: 7	MPNWGSLDH
SEQ ID NO: 8	MPNWGSFDS
SEQ ID NO: 9	MPNWGSLDT
SEQ ID NO: 10	MPNWGSLDA
SEQ ID NO: 11	MPNWGSLDN
SEQ ID NO: 12	MPNWGALDS
SEQ ID NO: 13	MPNWGSFDN
SEQ ID NO: 14	MPNWGSLDY
SEQ ID NO: 15	MPNWGSFDH
SEQ ID NO: 16	MPNWGSLDS
SEQ ID NO: 17	MPNWGSLDG
SEQ ID NO: 18	VPNWGSLDN
SEQ ID NO: 19	CARFPNWGSLDHWGQGTLVTVSSASIKG
SEQ ID NO: 20	CARMPNWGSLDHWGQGTLVTVSSASTKG
SEQ ID NO: 21	CARMPNWGSFDYWGQGTLVTVSSASIKG
SEQ ID NO: 22	VRMPNWGSLDHW
SEQ ID NO: 23	VRMPNWGSLDHWGQGTLVTVSSASIKG
SEQ ID NO: 24	ARMPNWGSLDHWGQGTLVTVSSASIKG
SEQ ID NO: 25	FPNWGSFDYWGQGTLVTVSSASIKG
SEQ ID NO: 26	VPNWGSLDA

Specific embodiments provide isolated antibody
5 molecules which include a heavy chain variable region
wherein CDR1, CDR2, and/or CDR3 sequences are SEQ ID NO:82,
SEQ ID NO:83 and/or SEQ ID NO:40, respectively; or
equivalents thereof characterized as having one or more
conservative amino acid substitutions in any one ore more of
10 the CDR sequences. Additional select embodiments provide

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isolated antibody molecules that include a heavy chain variable region wherein CDR1, CDR2, and/or CDR3 sequences are SEQ ID NO:82, SEQ ID NO:102, and/or SEQ ID NO:40, respectively; or equivalents thereof characterized as having
 5 one or more conservative amino acid substitutions in any one or more of the CDR sequences.

In particular embodiments, the present invention provides isolated IL-13R α 1 antibody molecules which have a variable light CDR3 sequence of SEQ ID NO:41, and
 10 conservative modifications thereof, which exhibit at least one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in
 15 NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; and (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs. Light chain variable region CDR3 sequences particularly embraced by the present invention are listed in Table 3.

20

TABLE 3

SEQ ID NO:	V _L CDR3 Sequence
SEQ ID NO: 27	QRYAT
SEQ ID NO: 28	QRYST
SEQ ID NO: 29	QMYST
SEQ ID NO: 30	QQVGT
SEQ ID NO: 31	QVYST
SEQ ID NO: 32	QQYST
SEQ ID NO: 33	QSYST
SEQ ID NO: 34	QQYAT
SEQ ID NO: 35	QQYSS
SEQ ID NO: 36	QTYST
SEQ ID NO: 37	QQYGS
SEQ ID NO: 38	QQYAS
SEQ ID NO: 39	QQYEA

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Specific embodiments provide isolated antibody molecules which include a light chain variable region wherein CDR1, CDR2, and/or CDR3 sequences are set forth in SEQ ID NO:84, SEQ ID NO:85, and/or SEQ ID NO:41, respectively; or an equivalent thereof characterized as having one or more conservative amino acid substitutions in any one or more of the CDR sequences.

In particular embodiments, the present invention provides isolated IL-13R α 1 antibody molecules which include heavy chain variable region CDR3 sequence and light chain variable region CDR3 sequence of SEQ ID NOs:40 and 41, respectively, or conservative modifications thereof in any one or more of the CDR3 sequences, that exhibit at least one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; and (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs.

Specific embodiments provide isolated IL-13R α 1 antibody molecules which include heavy chain variable region CDR1, CDR2, and CDR3 sequences and light chain variable region CDR1, CDR2, and CDR3 sequences of SEQ ID NOs:82, 83, 40, 84, 85 and 41, respectively; and equivalents thereof characterized as having one or more conservative amino acid substitutions in any one or more of the CDR sequences.

Conservative amino acid substitutions, as one of ordinary skill in the art will appreciate, are substitutions that replace an amino acid residue with one imparting similar or better (for the intended purpose) functional and/or chemical characteristics. For example, conservative amino acid substitutions are often ones in which the amino acid residue is replaced with an amino acid residue having a

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similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagines, glutamine, serine, threonine, tyrosine, cysteine, tryptophan), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine). Such modifications do not significantly reduce or alter the binding or functional inhibition characteristics of the antibody containing the amino acid sequence but may improve such properties. The purpose for making a substitution is not significant and can include, but is by no means limited to, replacing a residue with one better able to maintain or enhance the structure of the molecule, the charge or hydrophobicity of the molecule, or the size of the molecule. For instance, one may desire simply to substitute a less desired residue with one of the same polarity or charge. Such modifications can be introduced by standard techniques known in the art, such as site-directed mutagenesis and PCR-mediated mutagenesis. One specific means by which those of skill in the art accomplish conservative amino acid substitutions is alanine scanning mutagenesis as discussed in, for example, MacLennan et al., 1998 *Acta Physiol. Scand. Suppl.* 643:55-67, and Sasaki et al., 1998 *Adv. Biophys.* 35:1-24. The altered antibody molecules are then tested for retained or better function using functional assays available in the art or described herein. Antibody molecules possessing one or more such conservative amino acid substitutions which retain the ability to selectively bind to hIL-13R α 1 and antagonize IL-13R α 1 functioning at a level

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the same or better than the molecule not possessing such amino acid alterations are referred to herein as "functional equivalents" of the disclosed antibodies and form specific embodiments of the present invention.

5 In another aspect, the present invention provides antibody molecules which include heavy and/or light chain variable regions comprising amino acid sequences that are homologous to the corresponding amino acid sequences of the disclosed antibodies, wherein the antibody molecules exhibit
10 an equilibrium dissociation constant (K_D) of less than 5 nM with human interleukin 13 receptor $\alpha 1$ (hIL-13R $\alpha 1$) and antagonize hIL-13R $\alpha 1$ -mediated activity. Specific embodiments are antibody molecules which include heavy and/or light chain variable regions which are at least 90% homologous to
15 disclosed heavy and/or light chain variable regions, respectively, that exhibit at least one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of
20 IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; or (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs. Other embodiments of the present invention are antibody molecules which include heavy and/or
25 light chain variable regions which are at least 90% homologous to disclosed heavy and/or light chain variable regions, respectively, that compete for binding to hIL-13R $\alpha 1$ with an antibody as produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933. Reference to "at
30 least 90% homologous" in variable regions includes at least 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 and 100% homologous sequences.

Antibodies with amino acid sequences homologous to the amino acid sequences of the specific antibody molecules

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described herein are typically produced to improve one or more of the properties of the antibody without changing its specificity for IL-13R α 1. One method of obtaining such sequences, which is not the only method available to the skilled artisan, is to mutate sequence encoding heavy and/or light chain variable regions disclosed herein by site-directed or random mutagenesis, express an antibody molecule comprising the mutated variable region(s), and test the encoded antibody molecule for retained function using the functional assays described herein.

As used herein, the percent homology between two amino acid sequences is equivalent to the percent identity between the two sequences. The percent identity between the two sequences is a function of the number of identical positions shared by the sequences (*i.e.*, % homology = # of identical positions/total # of positions X 100), taking into account the number of gaps, and length of each gap, which need to be introduced for optimal alignment of the two sequences. The comparison of sequences and determination of percent identity between sequences can be determined using methods generally known to those in the art and can be accomplished using a mathematical algorithm. For example, the percent identity between amino acid sequences and/or nucleotide sequences can be determined using the algorithm of Meyers and Miller, 1988 *Comput. Appl. Biosci.* 4:11-17, which has been incorporated into the ALIGN program (version 2.0). In addition, the percent identity between amino acid sequences or nucleotide sequences can be determined using the GAP program in the GCG software package available online from Accelrys, using its default parameters.

Specific antibodies of the present invention inhibit the binding of IL-13 to hIL-13R α 1. Specific antibodies of the present invention compete for binding to hIL-13R α 1 with any of the antibodies disclosed herein and, particularly,

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10G5. Such competing antibodies can be identified based on their ability to cross-compete (e.g., to competitively inhibit the binding of, in a statistically significant manner) with 10G5 or its derivatives disclosed herein in
5 standard IL-13R α 1 binding assays. The ability of a test antibody to inhibit the binding of 10G5 or derivative to human IL-13R α 1 demonstrates that the test antibody can compete with that antibody for binding to human IL-13R α 1. Such an antibody may, according to non-limiting theory, bind
10 to the same or a related (e.g., a structurally similar or spatially proximal) epitope on human IL-13R α 1 as the antibody with which it competes. Antibodies that compete for binding with 10G5 or its disclosed derivatives may then be assessed for having at least one of the following functional
15 properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; and (v)
20 inhibition of IL-13-stimulated release of TARC in blood or PBMCs. The antibodies can also then be assessed for binding sensitivity at the Phe233Ala residue of human IL-13R α 1 described herein.

In particular embodiments, the present invention
25 provides isolated antibody molecules that antagonize IL-13R α 1 function (IL-13R α 1-mediated activity) and which exhibit an equilibrium dissociation constant (K_D) with hIL-13R α 1 which is less than 200 pM, and preferably less than 100 pM, as determined by surface plasmon resonance
30 technologies readily available and understood by those of skill in the art, including but not limited to, BIACORE™ (Upsala, Sweden) and KINEXA® (Sapidyne Instruments, Boise, ID) or suitable equivalent thereof. In specific embodiments,

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the isolated antibody molecules exhibit the above K_D as well as one of the following functional properties: (i) inhibition of IL-13-induced eotaxin release in NHDF cells; (ii) inhibition of IL-4-induced eotaxin release in NHDF
5 cells; (iii) inhibition of IL-13-induced STAT6 phosphorylation in NHDF cells; (iv) inhibition of IL-4-induced STAT6 phosphorylation in NHDF cells; and (v) inhibition of IL-13-stimulated release of TARC in blood or PBMCs.

10 In specific embodiments, the present invention provides isolated antibody molecules which exhibit the above K_D , antagonize IL-13 α 1-mediated activity, and comprise a heavy chain variable region with a complementarity determining region 3 (CDR3) domain as set forth in SEQ ID NO:5 or an
15 equivalent thereof characterized as having conservative amino acid substitutions at amino acid positions 1, 7, and/or 9 therein. In specific embodiments, the present invention provides isolated antibody molecules which exhibit the above K_D and heavy chain variable region and further
20 include a light chain variable region with a CDR3 domain as set forth in SEQ ID NO:38 or an equivalent thereof characterized as having conservative amino acid substitutions at amino acid positions 2, 4, and/or 5 therein. In specific embodiments, such conservative amino
25 acid substitutions encompass the following:

in SEQ ID NO:5, position 1, a substitution selected from the group consisting of: a F, M, Q, L and V;

in SEQ ID NO:5, position 7, a substitution selected from the group consisting of: a F, L, A and M;

30 in SEQ ID NO:5, position 9, a substitution selected from the group consisting of: a Y, Q, K, R, W and H;

in SEQ ID NO:38, position 2, a substitution selected from the group consisting of: Q, R, M, S and T;

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in SEQ ID NO:38, position 4, a substitution selected from the group consisting of: E, A, G and S; and/or

in SEQ ID NO:38, position 5, a substitution selected from the group consisting of: T, A and S.

5 Accordingly, one embodiment of the present invention embraces an antibody molecule with a heavy chain variable region CDR3 having the sequence Xaa₁-Pro-Asn-Trp-Gly-Xaa₂-Xaa₃-Asp-Xaa₄ (SEQ ID NO:121), wherein Xaa₁ is Phe, Met, Gln, Leu or Val; Xaa₂ is Ser or Ala; Xaa₃ is Phe, Leu, Ala or Met;
10 and Xaa₄ is Tyr, Gln, Lys, Arg, Trp, His, Ala, Thr, Ser, Asn or Gly. Another embodiment embraces an antibody molecule with a light chain variable region CDR3 having the sequence Gln-Xaa₁-Xaa₂-Xaa₃-Xaa₄ (SEQ ID NO:122), wherein Xaa₁ is Gln, Arg, Met, Ser, Thr or Val; Xaa₂ is Tyr or Val; Xaa₃ is Glu,
15 Ala, Gly or Ser; and Xaa₄ is Thr, Ala or Ser.

One aspect of the present invention is an isolated antibody or antigen binding fragment that includes:

a heavy chain variable region with a CDR3 domain having a sequence selected from the group consisting of: SEQ ID
20 NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:14, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:17, SEQ ID NO:18, and SEQ ID NO:26; or a heavy chain variable region
25 with a sequence including a CDR3 domain, said sequence selected from the group consisting of: SEQ ID NO:19, SEQ ID NO:20, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:23, SEQ ID NO:24, and SEQ ID NO:25; and/or

a light chain variable region with a CDR3 domain having
30 a sequence selected from the group consisting of: SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:35, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:38 and SEQ ID NO:39;

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wherein specific embodiments thereof exhibit a K_D with hIL-13R α 1 which is less than 200 pM.

Specific embodiments have a heavy chain including a sequence selected from the group consisting of: SEQ ID NO:50, SEQ ID NO:54, SEQ ID NO:58, SEQ ID NO:62, and SEQ ID NO:66. Specific embodiments have a heavy chain variable domain including a sequence selected from the group consisting of: SEQ ID NO:51, SEQ ID NO:55, SEQ ID NO:59, SEQ ID NO:63, and SEQ ID NO:67. Specific embodiments have a light chain having a sequence selected from the group consisting of: SEQ ID NO:70, SEQ ID NO:74, and SEQ ID NO:78. Specific embodiments have a light chain variable domain having a sequence selected from the group consisting of: SEQ ID NO:71, SEQ ID NO:75, and SEQ ID NO:79.

Another aspect of the present invention is an isolated antibody or antigen binding fragment in accordance with the present disclosure that possesses the following:

a light chain variable region including a CDR2 domain with the sequence set forth in SEQ ID NO:85;

a heavy chain variable region including a CDR2 domain with the sequence set forth in SEQ ID NO:83;

a light chain variable region including a CDR1 domain with the sequence set forth in SEQ ID NO:84; and/or

a heavy chain variable region including a CDR1 domain with the sequence set forth in SEQ ID NO:82. Accordingly, specific embodiments of the present invention provide antibody molecules specific for human IL-13 receptor which include an antigen binding region having heavy and light chain variable regions, and a set of CDRs (CDR1, CDR2, and CDR3) as described herein. The present invention also provides compositions including one and/or both of the following components (1) a heavy chain variable region having a set of CDRs, and (2) a light chain variable region having a set of CDRs.

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In one aspect, the present invention provides isolated antibody molecules for human IL-13R α 1 which have therein at least one light chain variable domain and at least one heavy chain variable domain (V_L and V_H , respectively).

5 In specific embodiments, an antibody molecule having a heavy chain variable chain region in accordance with the present description is expressed with a light chain variable region with CDR3 sequence as set forth in SEQ ID NO:41. In other embodiments, an antibody molecule having a light chain
10 variable region in accordance with the present description is expressed with a heavy chain variable sequence with CDR3 sequence as set forth in SEQ ID NO:40. In specific embodiments, light and heavy chains of the formulas described above are used in combination. Specific
15 embodiments of the present invention provide antibody molecules that further include the following:

a light chain variable region with a CDR2 domain as set forth in SEQ ID NO:85;

a heavy chain variable region with a CDR2 domain as set
20 forth in SEQ ID NO:83;

a light chain variable region with a CDR1 domain as set forth in SEQ ID NO:84; and/or

a heavy chain variable region with a CDR1 domain as set forth in SEQ ID NO:82, or suitable equivalents or
25 derivatives thereof, including said domains containing conservative amino acid substitutions as described above.

Any antibody molecule including the disclosed heavy and/or light CDRs, variable regions or light or heavy chains, or any combination thereof is encompassed within the
30 present invention including, but not limited to, the following antibody molecules: (1) an isolated antibody molecule having a heavy chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:5, and a light chain variable region having therein CDR3 sequence as set forth in

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SEQ ID NO:38; (2) an isolated antibody molecule having a heavy chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:5, and a light chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:39;

5 (3) an isolated antibody molecule having a heavy chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:5, and a light chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:41; (4) an isolated antibody molecule having a heavy chain variable

10 region having therein CDR3 sequence as set forth in SEQ ID NO:22, and a light chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:38; (5) an isolated antibody molecule having a heavy chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:23,

15 and a light chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:38; and (6) an isolated antibody molecule having a heavy chain variable region having therein CDR3 sequence as set forth in SEQ ID NO:7, and a light chain variable region having therein CDR3

20 sequence as set forth in SEQ ID NO:38.

In some embodiments, an isolated antibody of the present invention has a light chain variable region including a CDR2 domain with the sequence set forth in SEQ ID NO:85; a heavy chain variable region including a CDR2

25 domain with the sequence set forth in SEQ ID NO:83; a light chain variable region including a CDR1 domain with the sequence set forth in SEQ ID NO:84; and a heavy chain variable region including a CDR1 domain with the sequence set forth in SEQ ID NO:82.

30 In other embodiments an isolated antibody molecule of the invention has a heavy chain variable region with CDR1, CDR2 and CDR3 sequences as set forth in SEQ ID NO:82, SEQ ID NO:83, and SEQ ID NO:7 respectively, and a light chain variable region including CDR1, CDR2 and CDR3 sequences as

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set forth in SEQ ID NO:84, SEQ ID NO:85, and SEQ ID NO:38 respectively.

Further encompassed herein are antibody molecules including (i) a heavy chain variable region as set forth in
5 SEQ ID NO:63 and/or a light chain variable region as set forth in SEQ ID NO:71; (ii) a heavy chain as set forth in SEQ ID NO:62 and a light chain variable region as set forth in SEQ ID NO:71, and (iii) a heavy chain as set forth in SEQ ID NO:94 and a light chain variable region as set forth in
10 SEQ ID NO:71.

Manipulation of monoclonal and other antibodies to produce other antibodies or chimeric molecules which retain the specificity of the original antibody is well within the realm of one skilled in the art. This can be accomplished,
15 for example, using techniques of recombinant DNA technology. Such techniques may involve the introduction of DNA encoding the immunoglobulin variable region, or one or more of the CDRs, of an antibody to the variable region, constant region, or constant region plus framework regions, as
20 appropriate, of a different immunoglobulin. Such molecules form important aspects of the present invention. Specific immunoglobulins, into which the disclosed sequences may be inserted or, in the alternative, form the essential part of, include but are not limited to the following antibody
25 molecules which form particular embodiments of the present invention: a Fab (monovalent fragment with variable light (V_L), variable heavy (V_H), constant light (C_L) and constant heavy 1 (C_{H1}) domains), a $F(ab')_2$ (bivalent fragment comprising two Fab fragments linked by a disulfide bridge or
30 alternative at the hinge region), a Fd (V_H and C_{H1} domains), a Fv (V_L and V_H domains), a scFv (a single chain Fv where V_L and V_H are joined by a linker, e.g., a peptide linker, see, e.g., Bird et al., 1988 *Science* 242:423-426, Huston et al., 1988 *Proc. Natl. Acad. Sci. USA* 85:5879-5883), a bispecific

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antibody molecule (an antibody molecule comprising an IL-13R α 1-specific antibody or antigen binding fragment as disclosed herein linked to a second functional moiety having a different binding specificity than the antibody, including, without limitation, another peptide or protein such as an antibody, or receptor ligand), a bispecific single chain Fv dimer (see, e.g., PCT/US92/09965), an isolated CDR3, a minibody (single chain-C_{H3} fusion that self assembles into a bivalent dimer of about 80 kDa), a 'scAb' (an antibody fragment containing V_H and V_L as well as either C_L or C_{H1}), a dAb fragment (V_H domain, see, e.g., Ward et al., 1989 *Nature* 341:544-546, and McCafferty et al., 1990 *Nature* 348:552-554; or V_L domain; Holt et al., 2003 *Trends in Biotechnology* 21:484-489), a diabody (see, e.g., Holliger et al., 1993 *Proc. Natl. Acad. Sci. USA* 90:6444-6448 and WO 94/13804), a triabody, a tetrabody, a minibody (a scFv joined to a C_{H3}; see, e.g., Hu et al., 1996 *Cancer Res.* 56:3055-3061), IgG, IgG1, IgG2, IgG3, IgG4, IgM, IgD, IgA, IgE or any derivatives thereof, and artificial antibodies based upon protein scaffolds, including but not limited to fibronectin type III polypeptide antibodies (see, e.g., U.S. Patent No. 6,703,199 and WO 02/32925) or cytochrome B; see, e.g., Koide et al., 1998 *J. Mol. Biol.* 284:1141-1151, and Nygren et al., 1997 *Current Opinion in Structural Biology* 7:463-469. Certain antibody molecules including, but not limited to, Fv, scFv, and diabody molecules may be stabilized by incorporating disulfide bridges to line the V_H and V_L domains, see, e.g., Reiter et al., 1996 *Nature Biotech.* 14:1239-1245. Bispecific antibodies may be produced using conventional technologies (see, e.g., Holliger & Winter, 1993 *Current Opinion Biotechnol.* 4:446-449, specific methods of which include production chemically, or from hybrid hybridomas) and other technologies including, but not limited to, the BITE™ technology (molecules possessing

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antigen binding regions of different specificity with a peptide linker) and knobs-into-holes engineering (see, e.g., Ridgeway et al., 1996 *Protein Eng.* 9:616-621). Bispecific diabodies may be produced in *E. coli*, and these molecules as well as other antibody molecules, as one of skill in the art will appreciate, may be selected using phage display in the appropriate libraries (see, e.g., WO 94/13804).

Variable domains, into which CDRs of interest are inserted, may be obtained from any germ-line or rearranged human variable domain. Variable domains may also be synthetically produced. The CDR regions can be introduced into the respective variable domains using recombinant DNA technology. One means by which this can be achieved is described in Marks et al., 1992 *Bio/Technology* 10:779-783. Expression and selection may be achieved using suitable technologies including, but not limited to phage display (see, e.g., WO 92/01047, Kay et al., 1996 *Phage Display of Peptides and Proteins: A Laboratory Manual*, San Diego: Academic Press), yeast display, bacterial display, T7 display, and ribosome display (see, e.g., Lowe & Jermutus, 2004 *Curr. Pharm. Biotech.* 517-527). A variable heavy domain may be paired with a variable light domain to provide an antigen binding site. In addition, independent regions (e.g., a variable heavy domain alone) may be used to bind antigen. The artisan is well aware, as well, that two domains of an Fv fragment, V_L and V_H , while perhaps coded by separate genes, may be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the V_L and V_H regions pair to form monovalent molecules (scFvs).

Specific embodiments provide the CDR(s) in germline framework regions. Specific embodiments herein provide heavy chain CDR(s) of interest into VH5-51 (JH4) in place of the relevant CDR(s); as, for example, in SEQ ID NOs:50, 54, 58,

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62, and 66. Specific embodiments herein provide the light chain CDR(s) into V κ 3 A27 (JK1) in place of the relevant CDR(s); as, for example, in SEQ ID NOs:70, 74, and 78.

The present invention encompasses antibody molecules
5 that are human, humanized, deimmunized, chimeric and primatized. The invention also encompasses antibodies produced by the process of veneering; see, e.g., Mark et al., 1994 Handbook of Experimental Pharmacology, vol. 113: The pharmacology of monoclonal Antibodies, Springer-Verlag,
10 pp. 105-134 and U.S. Patent No. 6,797,492. "Human" in reference to the disclosed antibody molecules specifically refers to antibody molecules having variable and/or constant regions derived from human germline immunoglobulin sequences, wherein said sequences may, but need not, be
15 modified/alterd to have certain amino acid substitutions or residues that are not encoded by human germline immunoglobulin sequence. Such mutations can be introduced by methods including, but not limited to, random or site-specific mutagenesis *in vitro*, or by somatic mutation *in*
20 *vivo*. Specific examples of mutation techniques discussed in the literature are that disclosed in Gram et al., 1992 *Proc. Natl. Acad. Sci. USA* 89:3576-3580; Barbas et al., 1994 *Proc. Natl. Acad. Sci. USA* 91:3809-3813, and Schier et al., 1996 *J. Mol. Biol.* 263:551-567. These are only specific examples
25 and do not represent the only available techniques. There are a plethora of mutation techniques in the scientific literature which are available to, and widely appreciated by, the skilled artisan. "Humanized" in reference to the disclosed antibody molecules refers specifically to antibody
30 molecules wherein CDR sequences derived from another mammalian species, such as a mouse, are grafted onto human framework sequences. "Primatized" in reference to the disclosed antibody molecules refers to antibody molecules wherein CDR sequences of a non-primate are inserted into

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primate framework sequences, *see, e.g.*, WO 93/02108 and WO 99/55369.

Specific antibodies of the present invention are monoclonal antibodies and, in particular embodiments, are in one of the following antibody formats: IgD, IgA, IgE, IgM, IgG1, IgG2, IgG3, IgG4 or any derivative of any of the foregoing. The language "derivatives thereof" or "derivatives" includes, *inter alia*, (i) antibodies and antibody molecules with modifications in the framework or CDR regions of one or both variable regions (*i.e.*, V_H and/or V_L), (ii) antibodies and antibody molecules with manipulations in the constant regions of the heavy and/or light chains, and (iii) antibodies and antibody molecules that contain additional chemical moieties which are not normally a part of the immunoglobulin molecule (*e.g.*, pegylation)..

Manipulations of the variable regions can be within one or more of the V_H and/or V_L CDR regions. Site-directed mutagenesis or random mutagenesis can be performed to introduce the mutation(s) and the effect on antibody functional property of interest can be evaluated using can be evaluated by available *in vitro* or *in vivo* assays including those described herein.

Antibodies of the present invention also include those in which modifications have been made to the framework residues within V_H and/or V_L to improve one or more properties of the antibody of interest. Typically, such framework modifications are made to decrease the immunogenicity of the antibody. For example, one approach is to "backmutate" one or more framework residues to the corresponding germline sequence. More specifically, an antibody that has undergone somatic mutation may contain framework residues that differ from the germline sequence from which the antibody is derived. Such residues can be

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identified by comparing the antibody framework sequences to the germline sequences from which the antibody is derived. Such "backmutated" antibodies are also intended to be encompassed by the invention. Another type of framework
5 modification involves mutating one or more residues within the framework region, or even within one or more CDR regions, to remove T cell epitopes to thereby reduce the potential immunogenicity of the antibody. This approach is also referred to as "deimmunization" and is described in
10 further detail in U.S. Patent Publication No. 20030153043 by Carr *et al.*

In addition or alternative to modifications made within the framework or CDR regions, antibodies of the invention may be engineered to include modifications within the Fc
15 region, where present, typically to alter one or more functional properties of the antibody, such as serum half-life, complement fixation, Fc receptor binding, and/or antigen-dependent cellular cytotoxicity.

In one embodiment, the hinge region of C_{H1} is modified
20 such that the number of cysteine residues in the hinge region is altered, e.g., increased or decreased, to, for example, facilitate assembly of the light and heavy chains or to increase or decrease the stability of the antibody. This approach is described further in U.S. Patent No.
25 5,677,425 by Bodmer *et al.*

In another embodiment, the Fc hinge region of an antibody is mutated to decrease the biological half-life of the antibody. This approach is described in further detail in U.S. Patent No. 6,165,745 by Ward *et al.*

30 In another embodiment, the antibody is modified to increase its biological half-life. Various approaches are possible. For example, one or more of the following mutations can be introduced: Thr252Leu, Thr254Ser, Thr256Phe, as described in U.S. Patent No. 6,277,375 by

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Ward. Alternatively, to increase the biological half-life, the antibody can be altered within the C_{H1} or CL region to contain a salvage receptor binding epitope taken from two loops of a C_{H2} domain of an Fc region of an IgG, as described
5 in U.S. Patent Nos. 5,869,046 and 6,121,022 by Presta et al.

In yet other embodiments, the Fc region is altered by replacing at least one amino acid residue with a different amino acid residue to alter the effector function(s) of the antibody. For example, see U.S. Patent Nos. 5,624,821 and
10 5,648,260, both by Winter et al.

In another example, one or more amino acids selected from amino acid residues 329, 331 and 322 can be replaced with a different amino acid residue such that the antibody has altered C1q binding and/or reduced or abolished
15 complement dependent cytotoxicity (CDC). This approach is described in further detail in U.S. Patent No. 6,194,551 by Idusogie et al.

In another example, one or more amino acid residues within amino acid positions 231 and 239 are modified to
20 thereby alter the ability of the antibody to fix complement. This approach is described further in WO 94/29351 by Bodmer et al.

In yet another example, the Fc region is modified to increase the ability of the antibody to mediate antibody-
25 dependent cellular cytotoxicity (ADCC) and/or to increase the affinity of the antibody for an Fcγ receptor by modifying one or more amino acids; see for example WO 00/42072 by Presta. Moreover, the binding sites on human IgG1 for FcγR1, FcγRII, FcγRIII and FcRn have been mapped
30 and variants with improved binding have been described (see Shields et al, *J. Biol. Chem.* 276:6591-6604, 2001).

The concept of generating "hybrids" or "combinatorial" IgG forms comprising various antibody isotypes to hone in on desired effector functionality has generally been described;

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see, e.g., Tao et al., 1991 *J. Exp. Med.* 173:1025-1028. A specific embodiment of the present invention encompasses antibody molecules that possess specific manipulations in the Fc region which have been found to result in reduced binding to FcγR receptors or C1q on the part of the antibody. The present invention, therefore, encompasses antibodies in accordance with the present description that do not provoke (or provoke to a lesser extent) antibody-dependent cellular cytotoxicity (ADCC), complement-mediated cytotoxicity (CMC), or form immune complexes, while retaining normal pharmacokinetic (PK) properties. Specific embodiments of the present invention provide an antibody molecule as defined in accordance with the present invention which includes, as part of its immunoglobulin structure, the sequence set forth in SEQ ID NO:92. Figure 16 illustrates a comparison of IgG2m4 (as described in U.S. Patent Publication No. US20070148167(A1)), which contains SEQ ID NO:92, with the amino acid sequence of IgG1, IgG2, and IgG4. One specific example of the above-described embodiment is an antibody molecule including SEQ ID NO:94 which possesses sequence based off of a 10G5-6 antibody. Another specific example of the above-described embodiment is an antibody molecule including SEQ ID NO:96 which possesses sequence based off of an 10G5H6 antibody.

In still another embodiment, the glycosylation of an antibody is modified. For example, an aglycosylated antibody can be made (i.e., the antibody lacks glycosylation). Glycosylation can be altered to, for example, increase the affinity of the antibody for antigen. Such carbohydrate modifications can be accomplished by, for example, altering one or more sites of glycosylation within the antibody sequence. For example, one or more amino acid substitutions can be made that result in elimination of one or more variable region framework glycosylation sites to thereby

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eliminate glycosylation at that site. Such an approach is described in further detail in U.S. Pat. Nos. 5,714,350 and 6,350,861 by Co et al.

Additionally or alternatively, an antibody can be made
5 that has an altered type of glycosylation, such as a hypofucosylated antibody having reduced amounts of fucosyl residues or an antibody having increased bisecting GlcNac structures. Such altered glycosylation patterns have been demonstrated to increase the ADCC ability of antibodies.
10 Such carbohydrate modifications can be accomplished by, for example, expressing the antibody in a host cell with altered glycosylation machinery. Cells with altered glycosylation machinery have been described in the art and can be used as host cells in which to express recombinant antibodies of the
15 invention to thereby produce an antibody with altered glycosylation."

Specific antibody molecules may carry a detectable label, or may be conjugated to a toxin (e.g., a cytotoxin), a radioactive isotope, a radionuclide, a liposome, a
20 targeting moiety, a biosensor, a cationic tail, or an enzyme (e.g., via a peptidyl bond or linker). Such antibody molecule compositions form an additional aspect of the present invention.

In another aspect, the present invention provides
25 isolated nucleic acid encoding the disclosed antibody molecules. The nucleic acid may be present in whole cells, in a cell lysate, or in a partially purified or substantially pure form. A nucleic acid is "isolated" or "rendered substantially pure" when purified away from other
30 cellular components or other contaminants, e.g., other cellular nucleic acids or proteins, for example, using standard techniques, including without limitation, alkaline/SDS treatment, CsCl banding, column chromatography, agarose gel electrophoresis and other suitable methods known

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in the art. The nucleic acid may include DNA (inclusive of cDNA) and/or RNA. Nucleic acids of the present invention can be obtained using standard molecular biology techniques. For antibodies expressed by hybridomas (e.g., hybridomas
5 prepared from transgenic mice carrying human immunoglobulin genes), cDNAs encoding the light and heavy chains of the antibody made by the hybridoma can be obtained by standard PCR amplification or cDNA cloning techniques. For antibodies obtained from an immunoglobulin gene library (e.g., using
10 phage display techniques), nucleic acid encoding the antibody can be recovered from the library.

The present invention encompasses isolated nucleic acid encoding the disclosed variable heavy and/or light chains and select components thereof, particularly the disclosed
15 respective CDR3 regions. In specific embodiments hereof, the CDR(s) are provided within antibody framework regions. Specific embodiments provide isolated nucleic acid encoding the CDR(s) inserted into the germline framework regions. Specific embodiments herein provide isolated nucleic acid
20 encoding the heavy chain CDR(s) inserted into a VH5-51 (JH4) germline in place of the nucleic acid encoding the corresponding CDR(s); as, for example, in SEQ ID NOs:52, 56, 60, 64 and 68. Specific embodiments herein provide isolated nucleic acid encoding the light chain CDR(s) inserted into Vk3
25 A27 (JK1) germline in place of the nucleic acid encoding the corresponding CDR(s); as, for example, in SEQ ID NOs:72, 76 and 80. The isolated nucleic acid encoding the variable regions can be provided within any desired antibody molecule format including, but not limited to, the following: F(ab')₂,
30 a Fab, a Fv, a scFv, bispecific antibody molecules (antibody molecules comprising an IL-13R α 1-specific antibody or antigen binding fragment as disclosed herein linked to a second functional moiety having a different binding specificity than the antibody, including, without

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limitation, another peptide or protein such as an antibody, or receptor ligand), a bispecific single chain Fv dimer, a minibody, a dAb fragment, diabody, triabody or tetrabody, IgG, IgG1, IgG2, IgG3, IgG4, IgM, IgD, IgA, IgE or any
5 derivatives thereof.

Specific embodiments provide isolated a nucleic acid encoding an antibody molecule including a heavy chain having a sequence selected from the group consisting of SEQ ID NO:52, SEQ ID NO:56, SEQ ID NO:60, SEQ ID NO:64, and SEQ ID
10 NO:68. Specific embodiments provide isolated a nucleic acid encoding an antibody molecule including a heavy chain variable domain having a sequence selected from the group consisting of SEQ ID NO:43, SEQ ID NO:53, SEQ ID NO:57, SEQ ID NO:61, SEQ ID NO:65, and SEQ ID NO:69. Specific
15 embodiments of the present invention provide an isolated nucleic acid encoding an antibody molecule including (i) heavy chain CDR1 nucleotide sequence SEQ ID NO:106, (ii) heavy chain CDR2 nucleotide sequence SEQ ID NO:107, and/or (iii) heavy chain CDR3 nucleotide sequence SEQ ID NO:108 or
20 SEQ ID NO:112. Specific embodiments provide an isolated nucleic acid encoding an antibody molecule including a light chain having a sequence selected from the group consisting of SEQ ID NO:72, SEQ ID NO:76, and SEQ ID NO:80. Specific
embodiments provide an isolated nucleic acid encoding an
25 antibody molecule including a light chain variable domain having a sequence selected from the group consisting of SEQ ID NO:47, SEQ ID NO:73, SEQ ID NO:77, and SEQ ID NO:81. Specific
embodiments of the present invention provide an isolated nucleic acid encoding an antibody molecule
30 including (i) light chain CDR1 nucleotide sequence SEQ ID NO:109 or SEQ ID NO: 123, (ii) light chain CDR2 nucleotide sequence SEQ ID NO:110, and/or (iii) light chain CDR3 nucleotide sequence SEQ ID NO:111 or SEQ ID NO:113. Specific
embodiments of the present invention encompass a nucleic

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acid encoding an antibody molecule that possesses manipulations in the Fc region which result in reduced binding to FcγR receptors or C1q on the part of the antibody. One specific embodiment of the present invention is an isolated nucleic acid which includes SEQ ID NO:93. One specific example of such embodiment is an antibody molecule including the sequence of SEQ ID NO:95, or nucleic acid encoding an antigen binding fragment of SEQ ID NO:94. In specific embodiments, synthetic antibody molecules can be produced by expression from nucleic acid generated from oligonucleotides synthesized and assembled within suitable expression vectors; see, e.g., Knappick et al., 2000 *J. Mol. Biol.* 296:57-86, and Krebs et al., 2001 *J. Immunol. Methods* 254:67-84.

Also included within the present invention are nucleic acids including nucleotide sequences which are at least about 90% identical and more preferably at least about 95% identical to the nucleotide sequences described herein, and which nucleotide sequences encode antibodies of the present invention. Sequence comparison methods to determine identity are known to those skilled in the art and include those discussed earlier. Reference to "at least about 90% identical" includes at least about 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 or 100% identical.

The invention further provides nucleic acids that hybridize to the complement of nucleic acid disclosed herein (e.g., the complement of nucleic acid including (i) heavy chain nucleotide sequence SEQ ID NO:52, SEQ ID NO:56, SEQ ID NO:60, SEQ ID NO:64, SEQ ID NO:68 or SEQ ID NO:95, (ii) V_H nucleotide sequence SEQ ID NO:43, SEQ ID NO:53, SEQ ID NO:57, SEQ ID NO:61, SEQ ID NO:65 or SEQ ID NO:69; (iii) heavy chain CDR1 nucleotide sequence SEQ ID NO:106, (iv) heavy chain CDR2 nucleotide sequence SEQ ID NO:107, (v) heavy chain CDR3 nucleotide sequence SEQ ID NO:108 or SEQ ID

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NO:112, (vi) light chain nucleotide sequence SEQ ID NO:72, SEQ ID NO:76 or SEQ ID NO:0, (vii) V_L nucleotide sequence SEQ ID NO:47, SEQ ID NO:73, SEQ ID NO:77 or SEQ ID NO:81, (viii) light chain CDR1 nucleotide sequence SEQ ID NO:109 or SEQ ID NO: 123, (ix) light chain CDR2 nucleotide sequence SEQ ID NO:110, or (x) light chain CDR3 nucleotide sequence comprising SEQ ID NO:111 or SEQ ID NO:113) under particular hybridization conditions, which nucleic acids encode antibody molecules that bind specifically to hIL-13R α 1 and antagonize IL-13R α 1-mediated activity. Methods for hybridizing nucleic acids are well-known in the art; see, e.g., Ausubel, *Current Protocols in Molecular Biology*, John Wiley & Sons, N.Y., 6.3.1-6.3.6, 1989. As defined herein, moderately stringent hybridization conditions may use a prewashing solution containing 5X sodium chloride/sodium citrate (SSC), 0.5% w/v SDS, 1.0 mM EDTA (pH 8.0), hybridization buffer of about 50% v/v formamide, 6X SSC, and a hybridization temperature of 55°C (or other similar hybridization solutions, such as one containing about 50% v/v formamide, with a hybridization temperature of 42°C), and washing conditions of 60°C, in 0.5X SSC, 0.1% w/v SDS. A stringent hybridization condition may be at 6X SSC at 45°C, followed by one or more washes in 0.1X SSC, 0.2% SDS at 68°C. Furthermore, one of skill in the art can manipulate the hybridization and/or washing conditions to increase or decrease the stringency of hybridization such that nucleic acids comprising nucleotide sequences that are at least 65, 70, 75, 80, 85, 90, 95, 98, or 99% identical to each other typically remain hybridized to each other. The basic parameters affecting the choice of hybridization conditions and guidance for devising suitable conditions are set forth by Sambrook et al., *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, Chapters 9 and 11. 1989; and Ausubel et al. (eds). *Current*

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Protocols in Molecular Biology, John Wiley & Sons, Inc., sections 2.10 and 6.3-6.4, 1995, and can be readily determined by those having ordinary skill in the art based on, for example, the length and/or base composition of the
5 DNA.

The present invention provides isolated antibodies which include a light and/or heavy chain variable domain that is encoded at least in part by a nucleotide sequence that hybridizes under moderately stringent conditions to the
10 complement of a nucleic acid sequence encoding a light and/or heavy chain variable domain disclosed herein (e.g., selected from the group consisting of SEQ ID NO:43, SEQ ID NO:47, SEQ ID NO:53, SEQ ID NO:57, SEQ ID NO:61, SEQ ID NO:65, SEQ ID NO:69, SEQ ID NO:73, SEQ ID NO:77 and SEQ ID
15 NO:81). In another embodiment, the present invention encompasses isolated antibodies which include a light and/or heavy chain variable domain that is encoded at least in part by a nucleotide sequence that hybridizes under stringent conditions to the complement of a nucleic acid sequence
20 comprising a light and/or heavy chain variable domain disclosed herein.

In another aspect, the present invention provides vectors including said nucleic acid. Vectors in accordance with the present invention include, but are not limited to,
25 plasmids and other expression constructs (e.g., phage or phagemid, as appropriate) suitable for the expression of the desired antibody molecule at the appropriate level for the intended purpose; see, e.g., Sambrook & Russell, *Molecular Cloning: A Laboratory Manual: 3rd Edition*, Cold Spring Harbor
30 Laboratory Press. For most cloning purposes, DNA vectors may be used. Typical vectors include plasmids, modified viruses, bacteriophage, cosmids, yeast artificial chromosomes, and other forms of episomal or integrated DNA. It is well within the purview of the skilled artisan to determine an

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appropriate vector for a particular gene transfer, generation of a recombinant human antibody, or other use. In specific embodiments, in addition to a recombinant gene, the vector may also contain an origin of replication for autonomous replication in a host cell, appropriate regulatory sequences, such as a promoter, a termination sequence, a polyadenylation sequence, an enhancer sequence, a selectable marker, a limited number of useful restriction enzyme sites, other sequences as appropriate and the potential for high copy number. Examples of expression vectors for antibody and antibody fragment production are well-known in the art; see, e.g., Persic et al., 1997 *Gene* 187:9-18; Boel et al., 2000 *J. Immunol. Methods* 239:153-166, and Liang et al., 2001 *J. Immunol. Methods* 247:119-130. If desired, nucleic acid encoding an antibody may be integrated into the host chromosome using techniques well-known in the art; see, e.g., Ausubel, *Current Protocols in Molecular Biology*, John Wiley & Sons, 1999, and Marks et al., WO 95/17516. Nucleic acids may also be expressed on plasmids maintained episomally or incorporated into an artificial chromosome; see, e.g., Csonka et al., 2000 *J. Cell Science* 113:3207-3216; Vanderbyl et al., 2002 *Molecular Therapy* 5:10. The antibody light chain gene and the antibody heavy chain gene can be inserted into separate vector or, more typically, both genes are inserted into the same expression vector. The antibody genes are inserted into the expression vector by standard methods (e.g., ligation of complementary restriction sites on the antibody gene fragment and vector, or blunt end ligation if no restriction sites are present). The light and heavy chain variable regions of the antibodies described herein can be used to create full-length antibody genes of any antibody isotype by inserting them into expression vectors already encoding heavy chain constant and light chain constant regions of the desired isotype such

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that the V_H segment is operatively linked to the C_H segment(s) within the vector and the V_L segment is operatively linked to the C_L segment within the vector. Additionally or alternatively, the recombinant expression
5 vector can encode a signal peptide that facilitates secretion of the antibody chain from a host cell. The antibody chain gene can be cloned into the vector such that the signal peptide is linked in-frame to the amino terminus of the antibody chain gene. The signal peptide can be an
10 immunoglobulin signal peptide or a heterologous signal peptide (i.e., a signal peptide from a non-immunoglobulin protein). Any technique available to the skilled artisan may be employed to introduce the nucleic acid into the host cell; see, e.g., Morrison, 1985 *Science*, 229:1202. Methods
15 of subcloning nucleic acid molecules of interest into expression vectors, transforming or transfecting host cells containing the vectors, and methods of making substantially pure protein including the steps of introducing the respective expression vector into a host cell, and
20 cultivating the host cell under appropriate conditions are well-known. The antibody so produced may be harvested from the host cells in conventional ways. Techniques suitable for the introduction of nucleic acid into cells of interest will depend on the type of cell being used. General techniques
25 include, but are not limited to, calcium phosphate transfection, DEAE-Dextran, electroporation, liposome-mediated transfection and transduction using viruses appropriate to the cell line of interest (e.g., retrovirus, vaccinia, baculovirus, or bacteriophage).

30 In another aspect, the present invention provides isolated cell(s) including nucleic acid encoding the disclosed antibody molecules and components thereof as described. A variety of different cell lines can be used for recombinant production of antibody molecules, including but

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not limited to those from prokaryotic organisms (e.g., *E. coli*, *Bacillus*, and *Streptomyces*) and from eukaryotic (e.g., yeast, *Baculovirus*, and mammalian); see, e.g., Breitling et al., *Recombinant antibodies*, John Wiley & Sons, Inc. and Spektrum Akademischer Verlag, 1999. Plant cells, including transgenic plants, and animal cells, including transgenic animals (other than humans), including the nucleic acid or antibody molecules disclosed herein are also contemplated as part of the present invention. Suitable mammalian cell lines including, but not limited to, those derived from Chinese Hamster Ovary (CHO) cells, including but not limited to DHFR-CHO cells (described in Urlaub and Chasin, 1980 *Proc. Natl. Acad. Sci. USA* 77:4216-4220) used, for example, with a DHFR selectable marker (e.g., as described in Kaufman and Sharp, 1982 *Mol. Biol.* 159:601-621), NS0 myeloma cells (where a GS expression system as described in WO 87/04462, WO 89/01036, and EP 338,841 may be used), COS cells, SP2 cells, HeLa cells, baby hamster kidney cells, YB2/0 rat myeloma cells, human embryonic kidney cells, human embryonic retina cells, and others harboring the nucleic acid or antibody molecules disclosed herein form additional embodiments of the present invention. Specific embodiments of the present invention may employ *E. coli*; see, e.g., Plückthun, 1991 *Bio/Technology* 9:545-551, or yeast, such as *Pichia*, and recombinant derivatives thereof (see, e.g., Li et al., 2006 *Nat. Biotechnol.* 24:210-215). Additional specific embodiments of the present invention may employ eukaryotic cells for the production of antibody molecules, see, Chadd & Chamow, 2001 *Current Opinion in Biotechnology* 12:188-194, Andersen & Krummen, 2002 *Current Opinion in Biotechnology* 13:117, Larrick & Thomas, 2001 *Current Opinion in Biotechnology* 12:411-418. Specific embodiments of the present invention may employ mammalian cells able to produce antibody molecules with proper post-translational

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modifications. Post-translational modifications include, but are by no means limited to, disulfide bond formation and glycosylation. Another type of post-translational modification is signal peptide cleavage. Specific
5 embodiments herein have the appropriate glycosylation; see, e.g., Yoo et al., 2002 *J. Immunol. Methods* 261:1-20. Naturally occurring antibodies contain at least one N-linked carbohydrate attached to a heavy chain. *Id.* Different types of mammalian host cells can be used to provide for efficient
10 post-translational modifications. Examples of such host cells include Chinese Hamster Ovary (CHO), HeLa, C6, PC12, and myeloma cells; see, Yoo et al., 2002 *J. Immunol. Methods* 261:1-20, and Persic et al., 1997 *Gene* 187:9-18.

In another aspect, the present invention provides
15 isolated cell(s) comprising a polypeptide of the present invention.

In another aspect, the present invention provides a method of making an antibody molecule of the present invention, which involves incubating a cell harboring a
20 nucleic acid encoding a heavy and/or light chain (dictated by the desired antibody molecule) with specificity for human IL-13R α 1 under conditions that allow the expression and assembly of said heavy and/or light chains into an antibody molecule, and isolating said antibody molecule from the
25 cell. One example by which to generate the desired heavy and/or light chain sequence is to first amplify (and modify) the germline heavy and/or light chain variable sequences using PCR. Germline sequence for human heavy and/or light variable regions are readily available to the skilled
30 artisan, see, e.g., the "Vbase" human germline sequence database, and Kabat, E.A. et al., 1991 *Sequences of Proteins of Immunological Interest*, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242; Tomlinson, I.M. et al., 1992 "The Repertoire of Human

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Germline VH Sequences Reveals about Fifty Groups of VH Segments with Different Hypervariable Loops" *J. Mol. Biol.* 227:776-798; and Cox, J.P.L. et al., 1994 "A Directory of Human Germ-line Vk Segments Reveals a Strong Bias in their Usage" *Eur. J. Immunol.* 24:827-836. Mutagenesis of the germline sequences may be carried out using standard methods, e.g., PCR-mediated mutagenesis where the mutations are incorporated into the PCR primers, or site-directed mutagenesis. If full-length antibodies are desired, sequence is available for the human heavy chain constant region genes; see, e.g., Kabat. E.A. et al., 1991 *Sequences of Proteins of Immunological Interest*, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242. Fragments containing these regions may be obtained, for example, by standard PCR amplification. Alternatively, the skilled artisan can avail him/herself of vectors already encoding heavy and/or light chain constant regions.

Available techniques exist to recombinantly produce other antibody molecules which retain the specificity of an original antibody. A specific example of this is where DNA encoding the immunoglobulin variable region or the CDRs is introduced into the constant regions, or constant regions and framework regions, of another antibody molecule; see, e.g., EP-184,187, GB 2188638, and EP-239400, and scientific literature in the area. Cloning and expression of antibody molecules, including chimeric antibodies, are described in the literature; see, e.g., EP 0120694 and EP 0125023, and other scientific literature in the area.

Additional antibodies in accordance with the present invention can be raised and then screened for the characteristics identified herein using known techniques. Basic techniques for the preparation of monoclonal antibodies are described in the literature, see, e.g., Kohler and Milstein (1975, *Nature* 256:495-497). Fully human

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monoclonal antibodies are produced by available methods. These methods include, but are by no means limited to, the use of genetically engineered mouse strains which possess an immune system whereby the mouse antibody genes have been

5 inactivated and in turn replaced with a repertoire of functional human antibody genes, while leaving other components of the mouse immune system unchanged. Such genetically engineered mice allow for the natural *in vivo* immune response and affinity maturation process which

10 results in high affinity, full human monoclonal antibodies. This technology is well-known in the art and is fully detailed in various publications including, but not limited to, U.S. Patent Nos. 5,545,806; 5,569,825; 5,625,126; 5,633,425; 5,789,650; 5,877,397; 5,661,016; 5,814,318;

15 5,874,299; 5,770,249 (assigned to GenPharm International and available through Medarex, under the umbrella of the "UltraMab Human Antibody Development System"); as well as U.S. Patent Nos. 5,939,598; 6,075,181; 6,114,598; 6,150,584 and related family members (assigned to Abgenix, disclosing

20 their XENOMOUSE® technology). See also reviews from Kellerman and Green, 2002 *Curr. Opinion in Biotechnology* 13:593-597, and Kontermann & Stefan, 2001 *Antibody Engineering*, Springer Laboratory Manuals.

Alternatively, a library of antigen binding fragments

25 in accordance with the present invention may be brought into contact with IL-13R α 1, and ones able to demonstrate binding at the prescribed level, e.g., exhibiting a K_D with the antigen which is less than 200 pM and the ability to antagonize IL-13R α 1-mediated activity selected. Techniques

30 are available to the artisan for the selection of antibody fragments from libraries using enrichment technologies including, but not limited to, phage display (e.g., see technology from Cambridge Antibody Technology (CAT) disclosed in U.S. Patent Nos. 5,565,332; 5,733,743;

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5,871,907; 5,872,215; 5,885,793; 5,962,255; 6,140,471;
6,225,447; 6,291,650; 6,492,160; 6,521,404; 6,544,731;
6,555,313; 6,582,915; 6,593,081, as well as other U.S.
family members and/or applications which rely on priority
5 filing GB 9206318, filed May 24, 1992; see also Vaughn et
al., 1996, *Nature Biotechnology* 14:309-314), ribosome
display (see, e.g., Hanes and Pluckthün, 1997 *Proc. Natl.
Acad. Sci.* 94:4937-4942), bacterial display (see, e.g.,
Georgiou, et al., 1997 *Nature Biotechnology* 15:29-34) and/or
10 yeast display (see, e.g., Kieke, et al., 1997 *Protein
Engineering* 10:1303-1310). A library, for example, can be
displayed on the surface of bacteriophage particles, with
the nucleic acid encoding the antigen binding fragments
expressed and displayed on its surface. Nucleic acids may
15 then be isolated from bacteriophage particles exhibiting the
desired level of activity and the nucleic acids used in the
development of antibody molecules. Individual heavy or light
chain clones in accordance with the present invention may
also be used to screen for complementary heavy or light
20 chains, respectively, capable of interaction therewith to
form a molecule of the combined heavy and light chains; see,
e.g., WO 92/01047. Phage display has been described in the
literature; see, e.g., Kontermann & Stefan, *supra*, and WO
92/01047.

25 Monoclonal antibodies (MAbs) may be purified by
techniques available to one of skill in the art. Antibody
titers of the relevant ascites, hybridoma culture fluids, or
test sample of interest can be determined by various
serological or immunological assays which include, but are
30 not limited to, precipitation, passive agglutination,
enzyme-linked immunosorbent antibody (ELISA) techniques and
radioimmunoassay (RIA) techniques.

In another aspect, the present invention provides a
method for antagonizing the activity of IL-13R α 1, which

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involves contacting a cell expressing IL-13R α 1 with an antibody molecule disclosed herein under conditions that allow said antibody molecule to bind to IL-13R α 1. Specific embodiments of the present invention include such methods
5 wherein the cell is a human cell.

In another aspect, the present invention provides a method for antagonizing the activity of IL-13R α 1 in a subject exhibiting a condition associated with IL-13R α 1 activity, which involves administering to the subject a
10 therapeutically effective amount of an antibody molecule of the present invention. "Antagonizing" herein refers to the act of opposing, counteracting or curtailing one or more functions of the target, be that binding, signaling or other. Inhibition or antagonism of one or more of the IL-
15 13R α 1 functional properties can be readily determined according to methodologies known to the art as well as those described herein. It will, furthermore, be understood that such inhibition or antagonism should effectuate a decrease in the particular activity relative to that seen in the
20 absence of the antibody or, for example, that seen when a control antibody of irrelevant specificity is present. Preferably, an antibody molecule in accordance with the present invention antagonizes IL-13 and/or IL-4-mediated IL-13R α 1 functioning to the point that there is a decrease of
25 at least 10%, of the measured parameter, and more preferably, a decrease of at least 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 95% of the measured parameter. Such inhibition/antagonism of IL-13R α 1 functioning is particularly effective in those instances where receptor
30 functioning is contributing at least in part to a particular phenotype, disease, disorder or condition which is negatively impacting the subject.

Also contemplated are methods of using the disclosed antibody molecules in the manufacture of a medicament for

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treatment of an IL-13R α 1-mediated disease, disorder or condition. Thus, in another aspect, the present invention provides a pharmaceutically acceptable composition comprising an antibody molecule of the invention and a pharmaceutically acceptable carrier, excipient, diluent, stabilizer, buffer, or alternative designed to facilitate administration of the antibody molecule in the desired format and amount to the treated individual. Antibody molecules disclosed herein can be used in a method of treatment or diagnosis of a particular individual (human or primate). The method of treatment can be prophylactic or therapeutic in nature. Methods of treatment in accordance with the present invention include administering to an individual a therapeutically (or prophylactically) effective amount of an antibody molecule of the present invention. "Therapeutically effective" or "prophylactically effective" amount refers to the amount necessary at the intended dosage to achieve the desired therapeutic/prophylactic effect for the period of time desired. The desired effect may be, for example, amelioration of at least one symptom associated with the treated condition. These amounts will vary, as the skilled artisan will appreciate, according to various factors, including but not limited to the disease state, age, sex and weight of the individual, and the ability of the antibody molecule to elicit the desired effect in the individual. The response may be documented by *in vitro* assay, *in vivo* non-human animal studies, and/or further supported from clinical trials. The antibody-based pharmaceutical composition of the present invention may be formulated by any number of strategies known in the art, see, e.g., McGoff and Scher, 2000 *Solution Formulation of Proteins/Peptides*, In: McNally, E.J., ed. *Protein Formulation and Delivery*, New York, NY: Marcel Dekker; pp. 139-158; Akers & Defilippis, 2000, *Peptides and Proteins as*

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Parenteral Solutions, In: *Pharmaceutical Formulation Development of Peptides and Proteins*, Philadelphia, PA: Taylor and Francis; pp. 145-177; Akers et al., 2002, *Pharm. Biotechnol.* 14:47-127. A pharmaceutically acceptable composition suitable for patient administration will contain an effective amount of the antibody molecule in a formulation which both retains biological activity while also promoting maximal stability during storage within an acceptable temperature range.

10 The antibody-based pharmaceutically acceptable composition may be in liquid or solid form. Any technique for production of liquid or solid formulations may be utilized. Such techniques are well within the realm of the abilities of the skilled artisan. Solid formulations may be produced by any available method including, but not limited to, lyophilization, spray drying, or drying by supercritical fluid technology. Solid formulations for oral administration may be in any form rendering the antibody molecule accessible to the patient in the prescribed amount and within the prescribed period of time. The oral formulation can take the form of a number of solid formulations including, but not limited to, a tablet, capsule, or powder. Solid formulations may alternatively be lyophilized and brought into solution prior to administration for either single or multiple dosing. Antibody compositions should generally be formulated within a biologically relevant pH range and may be buffered to maintain a proper pH range during storage. Both liquid and solid formulations generally require storage at lower temperatures (e.g., 2-8°C) in order to retain stability for longer periods. Formulated antibody compositions, especially liquid formulations, may contain a bacteriostat to prevent or minimize proteolysis during storage, including but not limited to effective concentrations (e.g., ≤1% w/v) of benzyl alcohol, phenol, m-

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cresol, chlorobutanol, methylparaben, and/or propylparaben. A bacteriostat may be contraindicated for some patients. Therefore, a lyophilized formulation may be reconstituted in a solution either containing or not containing such a component. Additional components may be added to either a buffered liquid or solid antibody formulation, including but not limited to sugars as a cryoprotectant (including but not limited to polyhydroxy hydrocarbons such as sorbitol, mannitol, glycerol, and dulcitol and/or disaccharides such as sucrose, lactose, maltose, or trehalose) and, in some instances, a relevant salt (including but not limited to NaCl, KCl, or LiCl). Such antibody formulations, especially liquid formulations slated for long term storage, will rely on a useful range of total osmolarity to both promote long term stability at temperatures of, for example, 2-8°C or higher, while also making the formulation useful for parenteral injection. As appropriate, preservatives, stabilizers, buffers, antioxidants and/or other additives may be included. The formulations may contain a divalent cation (including but not limited to $MgCl_2$, $CaCl_2$, and $MnCl_2$); and/or a non-ionic surfactant (including but not limited to Polysorbate-80 (TWEEN 80™), Polysorbate-60 (TWEEN 60™), Polysorbate-40 (TWEEN 40™), and Polysorbate-20 (TWEEN 20™), polyoxyethylene alkyl ethers, including but not limited to BRIJ 58™, BRIJ 35™, as well as others such as TRITON X-100™, TRITON X-114™, NP40™, Span 85 and the PLURONIC® series of non-ionic surfactants (e.g., PLURONIC® 121). Any combination of such components form specific embodiments of the present invention.

Pharmaceutical compositions in liquid format may include a liquid carrier, e.g., water, petroleum, animal oil, vegetable oil, mineral oil, or synthetic oil. The liquid format may also include physiological saline solution, dextrose or other saccharide solution or glycols,

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such as ethylene glycol, propylene glycol or polyethylene glycol.

The pharmaceutical composition may be in the form of a parenterally acceptable aqueous solution that is pyrogen-free with suitable pH, tonicity, and stability. Pharmaceutical compositions may be formulated for administration after dilution in isotonic vehicles, for example, Sodium Chloride Injection, Ringer's Injection, or Lactated Ringer's Injection.

10 Dosing of antibody therapeutics is well within the realm of the skilled artisan, *see, e.g., Lederman et al., 1991 Int. J. Cancer 47:659-664; Bagshawe et al., 1991 Antibody, Immunoconjugates and Radiopharmaceuticals 4:915-922*, and will vary based on a number of factors including
15 but not limited to the antibody molecule utilized, the patient being treated, the condition of the patient, the area being treated, the route of administration, and the treatment desired. A physician or veterinarian of ordinary skill can readily determine and prescribe the effective
20 therapeutic amount of the antibody. Dosage ranges may be from about 0.01 to 100 mg/kg, and more usually 0.05 to 25 mg/kg, of the host body weight. For example, dosages can be 0.3 mg/kg body weight, 1 mg/kg body weight, 3 mg/kg body weight, 5 mg/kg body weight or 10 mg/kg body weight or
25 within the range of 1-10 mg/kg. For purposes of illustration, and not limitation, in specific embodiments, a dose of 5 mg to 2.0 g may be utilized to deliver the antibody molecule systemically. Optimal precision in achieving concentrations of antibody within a range that
30 yields efficacy without toxicity requires a regimen based on the kinetics of the drug's availability to the target site(s). This involves a consideration of the distribution, equilibrium, and elimination of the antibody molecule. Antibodies described herein may be used alone at appropriate

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dosages. Alternatively, co-administration or sequential administration of other agents may be desirable. It will be possible to present a therapeutic dosing regime for the antibody molecules of the present invention in conjunction
5 with alternative treatment regimes. Individuals (subjects) capable of treatment include primates, human and non-human, and include any non-human mammal or vertebrate of commercial or domestic veterinary importance.

The antibody molecule could be administered to an
10 individual by any route of administration appreciated in the art, including but not limited to oral administration, administration by injection (specific embodiments of which include intravenous, subcutaneous, intraperitoneal or intramuscular injection), administration by inhalation,
15 intranasal, or topical administration, either alone or in combination with other agents designed to assist in the treatment of the individual. The route of administration should be determined based on a number of considerations appreciated by the skilled artisan including, but not
20 limited to, the desired physiochemical characteristics of the treatment. Treatment may be provided on a daily, weekly, biweekly, or monthly basis, or any other regimen that delivers the appropriate amount of antibody molecule to the individual at the prescribed times such that the desired
25 treatment is effected and maintained. The formulations may be administered in a single dose or in more than one dose at separate times.

In particular embodiments, the condition treated is selected from the group consisting of asthma, allergy,
30 allergic rhinitis, chronic sinusitis, hay fever, atopic dermatitis, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, esophageal eosinophilia, psoriasis, psoriatic arthritis, fibrosis, scleroderma, inflammatory bowel disease (particularly, ulcerative colitis),

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anaphylaxis, and cancer (particularly, Hodgkin's lymphoma, glioma, and renal carcinoma), and general Th2-mediated disorders/conditions.

The present invention further provides for the
5 administration of the disclosed anti-hIL-13R α 1 antibody molecules for purposes of gene therapy. In such a method, the cells of a subject would be transformed with nucleic acid encoding the antibody molecules of the invention. Subjects comprising the nucleic acids will then produce the
10 antibody molecules endogenously. Previously, Alvarez, et al, *Clinical Cancer Research* 6:3081-3087, 2000, introduced single-chain anti-ErbB2 antibodies to subjects using a gene therapy approach. The methods disclosed by Alvarez, et al, may be easily adapted for the introduction of nucleic acids
15 encoding an anti-hIL-13R α 1 antibody of the invention to a subject.

Nucleic acids encoding any polypeptide or antibody molecule of the invention may be introduced to a subject. In specific embodiments, the antibody molecule is a human,
20 single-chain antibody.

The nucleic acids may be introduced to the cells of a subject by any means known in the art. In specific embodiments, the nucleic acids are introduced as part of a viral vector. Examples of particular viruses from which the
25 vectors may be derived include lentiviruses, herpes viruses, adenoviruses, adeno-associated viruses, vaccinia virus, baculovirus, alphavirus, influenza virus, and other recombinant viruses with desirable cellular tropism.

Various companies produce viral vectors commercially,
30 including, but by no means limited to, AVIGEN, Inc. (Alameda, CA; AAV vectors), Cell Genesys (Foster City, CA; retroviral, adenoviral, AAV vectors, and lentiviral vectors), CLONTECH (retroviral and baculoviral vectors), Genovo, Inc. (Sharon Hill, PA; adenoviral and AAV vectors),

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GENVEC (adenoviral vectors), IntroGene (Leiden, Netherlands; adenoviral vectors), Molecular Medicine (retroviral, adenoviral, AAV, and herpes viral vectors), Norgen (adenoviral vectors), Oxford BioMedica (Oxford, United Kingdom; lentiviral vectors), and Transgene (Strasbourg, France; adenoviral, vaccinia, retroviral, and lentiviral vectors).

Methods for constructing and using viral vectors are known in the art (see, e.g., Miller, et al, *BioTechniques* 7:980-990, 1992). In specific embodiments, the viral vectors are replication defective, that is, they are unable to replicate autonomously, and thus are not infectious, in the target cell. The replication defective virus may be a minimal virus, i.e., it retains only the sequences of its genome which are necessary for encapsidating the genome to produce viral particles. Defective viruses which entirely or almost entirely lack viral genes may be used as well. Use of defective viral vectors allows for administration to cells in a specific, localized area, without concern that the vector can infect other cells. Thus, a specific tissue can be specifically targeted.

Examples of vectors comprising attenuated or defective DNA virus sequences include, but are not limited to, a defective herpes virus vector (Kanno et al, *Cancer Gen. Ther.* 6:147-154, 1999; Kaplitt et al, *J. Neurosci. Meth.* 71:125-132, 1997 and Kaplitt et al, *J. Neuro Onc.* 19:137-147, 1994).

Adenoviruses are eukaryotic DNA viruses that can be modified to efficiently deliver a nucleic acid of the invention to a variety of cell types. Attenuated adenovirus vectors, such as the vector described by Strafford-Perricaudet et al, *J. Clin. Invest.* 90:626-630, 1992 are desirable in some instances. Various replication defective adenovirus and minimum adenovirus vectors have been

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described (see, e.g., WO94/26914, WO94/28938, WO94/28152, WO94/12649, WO95/02697 and WO96/22378). The replication defective recombinant adenoviruses according to the invention can be prepared by any technique known to a person skilled in the art (Levrero et al, *Gene* 101:195, 1991; EP 185573; Graham, *EMBO J.* 3:2917, 1984; Graham et al, *J. Gen. Virol.* 36:59, 1977).

The adeno-associated viruses (AAV) are DNA viruses of relatively small size which can integrate, in a stable and site-specific manner, into the genome of the cells which they infect. They are able to infect a wide spectrum of cells without inducing any effects on cellular growth, morphology or differentiation, and they do not appear to be involved in human pathologies. The use of vectors derived from the AAVs for transferring genes *in vitro* and *in vivo* has been described (see Daly, et al, *Gene Ther.* 8:1343-1346, 2001, Larson et al, *Adv. Exp. Med. Bio.* 489:45-57, 2001; WO 91/18088 and WO 93/09239; U.S. Patent Nos. 4,797,368 and 5,139,941 and EP 488528B1).

In another embodiment, the gene can be introduced in a retroviral vector, e.g., as described in U.S. Patent Nos. 5,399,346, 4,650,764, 4,980,289, and 5,124,263; Mann et al, *Cell* 33:153, 1983; Markowitz et al, *J. Virol.*, 62:1120, 1988; EP 453242 and EP178220. The retroviruses are integrating viruses which infect dividing cells.

Lentiviral vectors can be used as agents for the direct delivery and sustained expression of nucleic acids encoding an antibody molecule of the invention in several tissue types, including brain, retina, muscle, liver and blood. The vectors can efficiently transduce dividing and nondividing cells in these tissues, and maintain long-term expression of the antibody molecule. For a review, see Zufferey et al, *J. Virol.* 72:9873-80, 1998 and Kafri et al, *Curr. Opin. Mol. Ther.* 3:316-326, 2001. Lentiviral packaging cell lines are

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available and known generally in the art. They facilitate the production of high-titer lentivirus vectors for gene therapy. An example is a tetracycline-inducible VSV-G pseudotyped lentivirus packaging cell line which can generate virus particles at titers greater than 10^6 IU/ml for at least 3 to 4 days; see Kafri et al, *J. Virol.* 73:576-584, 1999. The vector produced by the inducible cell line can be concentrated as needed for efficiently transducing nondividing cells in vitro and in vivo.

Sindbis virus is a member of the alphavirus genus and has been studied extensively since its discovery in various parts of the world beginning in 1953. Gene transduction based on alphavirus, particularly Sindbis virus, has been well-studied in vitro (see Straus et al, *Microbiol. Rev.*, 58:491-562, 1994; Bredenbeek et al, *J. Virol.*, 67:6439-6446, 1993; Ijima et al, *Int. J. Cancer* 80:110-118, 1999 and Sawai et al, *Biochim. Biophys. Res. Comm.* 248:315-323, 1998. Many properties of alphavirus vectors make them a desirable alternative to other virus-derived vector systems being developed, including rapid engineering of expression constructs, production of high-titered stocks of infectious particles, infection of nondividing cells, and high levels of expression (Strauss et al, 1994 *supra*). Use of Sindbis virus for gene therapy has been described. (Wahlfors et al, *Gene. Ther.* 7:472-480, 2000 and Lundstrom, *J. Recep. Sig. Transduct. Res.* 19(1-4):673-686, 1999.

In another embodiment, a vector can be introduced to cells by lipofection or with other transfection facilitating agents (peptides, polymers, etc.). Synthetic cationic lipids can be used to prepare liposomes for *in vivo* and *in vitro* transfection of a gene encoding a marker (Feigner et al, *Proc. Natl. Acad. Sci. USA* 84:7413-7417, 1987 and Wang et al, *Proc. Natl. Acad. Sci. USA* 84:7851-7855, 1987). Useful lipid compounds and compositions for transfer of nucleic

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acids are described in WO 95/18863 and WO 96/17823, and in U.S. Patent No. 5,459,127.

It is also possible to introduce the vector *in vivo* as a naked DNA plasmid. Naked DNA vectors for gene therapy can be introduced into the desired host cells by methods known in the art, e.g., electroporation, microinjection, cell fusion, DEAE-dextran, calcium phosphate precipitation, use of a gene gun, or use of a DNA vector transporter (see, e.g., Wilson, et al, *J. Biol. Chem.* 267:963-967, 1992; Williams et al, *Proc. Natl. Acad. Sci. USA* 88:2726-2730, 1991). Receptor-mediated DNA delivery approaches can also be used (Wu et al, *J. Biol. Chem.* 263:14621-14624, 1988). U.S. Patent Nos. 5,580,859 and 5,589,466 disclose delivery of exogenous DNA sequences, free of transfection facilitating agents, in a mammal. Recently, a relatively low voltage, high efficiency *in vivo* DNA transfer technique, termed electrotransfer, has been described (Vilquin et al, *Gene Ther.* 8:1097, 2001; Payen et al, *Exp. Hematol.* 29:295-300, 2001; Mir, *Bioelectrochemistry* 53:1-10, 2001; WO 99/01157, WO 99/01158 and WO 99/01175).

Pharmaceutical compositions suitable for such gene therapy approaches and comprising nucleic acids encoding an anti-hIL-13R α 1 antibody molecule of the present invention are included within the scope of the present invention.

In another aspect, the present invention provides a method for identifying, isolating, quantifying or antagonizing IL-13R α 1 in a sample of interest using an antibody molecule of the present invention. The antibody molecules may be utilized as a research tool in immunochemical assays, such as western blots, ELISAs, radioimmunoassay, immunohistochemical assays, immunoprecipitations, or other immunochemical assays known in the art (see, e.g., *Immunological Techniques Laboratory Manual*, ed. Goers, J. 1993, Academic Press) or various

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purification protocols. The antibody molecules may have a label to facilitate ready identification or measurement of the activities associated therewith. One skilled in the art is readily familiar with the various types of detectable
5 labels (e.g., enzymes, dyes, or other suitable molecules which are either readily detectable or cause some activity/result that is readily detectable) useful in the above protocols.

Additional aspects of the present invention are kits
10 including the antibody molecules or pharmaceutical compositions disclosed herein and instructions for use. Kits typically but need not include a label indicating the intended use of the contents of the kit. The term label includes any writing, or recorded material supplied on or
15 with the kit, or which otherwise accompanies the kit.

Related to yet another aspect of the present invention, a critical contact point between the antibodies disclosed herein and the hIL-13R α 1 receptor was identified. This critical contact point was identified by introducing a
20 specific mutation that impacted the binding of the receptor by the antibody. More specifically, it was found that substitution of the phenylalanine residue at position 233 of SEQ ID NO:101 with an alanine residue results in a loss of binding between the antibody and the mutant receptor
25 compared with the binding between the antibody and wild type receptor. This is a very useful finding in characterizing 10G5 and its derivatives. Peptides exploiting the region surrounding amino acid 233 will be useful in the generation of additional monoclonal antibodies with similar
30 specificity. Accordingly, the present invention encompasses isolated peptides including a hIL-13R sequence with a Phe233Ala mutation (i.e. SEQ ID NO:120), whether they be full-length or fragments thereof (e.g., 5 to 350 amino acid residue fragments) including the mutation. Additionally, the

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present invention also encompasses the use of said peptides in an assay to evaluate 10G5 or 10G5 derivatives, identify antibodies with specificity for a similar epitope or, alternatively, produce antibodies with similar specificity.

5 In specific embodiments the present invention, therefore, provides a method of screening for antibody molecules that target the same region on hIL-13R α 1 as the antibody produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933, which involves (a) analyzing binding of an

10 antibody molecule of interest to (i) an isolated hIL-13R α 1 polypeptide of SEQ ID NO:101 or fragment thereof including the amino acid corresponding to residue 233 of SEQ ID NO:101; and (ii) an isolated polypeptide or fragment of an isolated hIL-13R α 1 polypeptide or fragment thereof wherein

15 the amino acid corresponding to residue 233 of SEQ ID NO:101 is an alanine rather than a phenylalanine; (b) identifying those antibodies that bind to the isolated polypeptide or fragment of step (a)(i) but exhibit significantly reduced binding to the isolated polypeptide or fragment of step (a)

20 (ii); and (c) recovering the antibodies identified in step (b). A significant decrease is typically more than a 10-fold reduction in binding between an antibody and the mutant receptor compared with the binding between the antibody and wild type receptor. Polypeptides that are useful in the

25 method are those fragments of SEQ ID NO:101 including the amino acid corresponding to residue 233 of SEQ ID NO:101 that bind to the antibody produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933, and the corresponding fragments wherein the amino acid corresponding

30 to residue 233 of SEQ ID NO:101 is an alanine rather than a phenylalanine. For example, the extracellular region of human IL-13R α 1 (amino acids number 1 to 317 of SEQ ID NO:101) may be used along with its corresponding Phe233Ala mutant.

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Another aspect of the invention includes an isolated antibody that (i) competes with the antibody produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933 for binding to hIL-13R α 1; (ii) inhibits IL-13 signaling; and
5 (iii) wherein a substitution in a hIL-13R α 1 peptide of the phenylalanine residue that corresponds to position 233 of SEQ ID NO:101 with an alanine residue leads to a loss of binding between said antibody and the resultant mutant hIL-13R α 1 peptide compared to the binding between said antibody
10 and the hIL-13R α 1 peptide without said substitution.

The invention is described in greater detail by the following non-limiting examples.

Example 1: Production and Purification of a Recombinant Protein Based on the Human IL-13R α 1 Extracellular Region

15 Using the protocol described herein, an N-terminal FLAG[®]-tagged fusion protein including most of the extracellular region of human IL-13R α 1 (amino acids number 3 to 317 of SEQ ID NO:101) was purified from culture media conditioned by a stably transfected (pEFBOS-S-FLAG[®] vector
20 encoding IL-13R α 1.ECR) CHO cell clone. The purified hIL-13R α 1.ECR protein (SEQ ID NO:103) was concentrated and subsequently desalted into phosphate-buffered saline (PBS), 0.02% v/v TWEEN[™] 20, followed by filter sterilization. Typical recovery was 0.4 mg protein per liter of conditioned
25 media. Protein was stored at -80°C until required.

Methods. A pEFBOS-S-FLAG[®] expression vector incorporating a cDNA encoding the extracellular region (ECR) of human IL-13R α 1 with an IL-3 signal sequence and FLAG[®]-tag fusion was transfected into CHO cells for stable expression
30 using standard procedures. CHO-derived conditioned media was then concentrated 10-fold by ultrafiltration using a 10 kDa cut-off membrane. Concentrated media was applied to an M2 (anti-FLAG[®]) affinity chromatography column and eluted with FLAG[®] peptide at a concentration of 100 μ g/ml. The eluate

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was concentrated by lyophilization and then buffer exchanged into Tris pH 8.0 using GF50 SEPHAROSE™ resin packed into column (2.6 cm x 40 cm). The buffer exchanged fraction was then subjected to anion exchange chromatography using a MONO™ Q 5/5 column. A proteolysed fragment of IL-13R α 1 was strongly retained and was separated from the full-length IL-13R α 1 which eluted at a lower salt concentration. Pooled fractions and filter sterilized final product was assessed by SDS-PAGE and western blot analysis. The sample was then quantitated using UV absorbance, where 1 absorbance unit was approximately 1 mg/ml.

Example 2: Generation of Hybridoma Cell Lines Producing Human Anti-Human IL-13R α 1 Monoclonal Antibodies

Immunization of Transgenic Mice. Male and female transgenic mice from the HCo7, HCo12 and HCo7xHCo12 strains (HUMAB™ mice, Medarex, USA) were immunized with hIL-13R α 1.ECR of Example 1. For the first immunization, 20-50 μ g of hIL-13R α 1.ECR was emulsified in Complete Freund's Adjuvant (CFA) and administered via the intraperitoneal (i.p.) route. For a minimum of two and a maximum of three subsequent i.p. immunizations, 20-50 μ g of hIL-13R α 1.ECR was emulsified in Incomplete Freund's Adjuvant (IFA). Following the second or third immunization with hIL-13R α 1.ECR in IFA, serum was sampled (retro-orbital plexus) and assayed for human antibodies against the hIL-13R α 1.ECR by ELISA as described herein. High-responder mice (serum titers generally >1:3200) were selected for hybridoma generation. In some cases, animals not used for hybridoma generation at this point received further i.p. immunizations with 20-50 μ g of hIL-13R α 1.ECR in PBS. Serum from these animals was again assayed for human antibodies against the hIL-13R α 1.ECR by ELISA and high-responder mice were used for hybridoma generation. Mice selected for hybridoma generation were

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boosted intravenously with 20-50 µg of hIL-13Rα1.ECR 3-4 days prior to spleen cell fusion.

Antigen-Specific ELISA. Mouse serum or hybridoma culture supernatant fluid (SNF) was assessed for mAbs able to bind to plate bound hIL-13Rα1.ECR using a standard ELISA format as follows. Flat bottom 96-well MAXISORP™ plates (NUNC, Invitro Technologies, #439454) were coated with 50 µl of a solution containing 2.5 µg/ml hIL-13Rα1.ECR diluted in PBS and incubated overnight at 4°C. After washing two times with PBS, plates were blocked with 2% w/v skim milk in PBS (blocking buffer, 200 µl/well) for 1 hour at 37°C, then washed a further two times with PBS containing 0.1% v/v TWEEN™ 20 (wash buffer). Fifty µl of test hybridoma SNF or mouse serum was added per well and plates were incubated at room temperature for 1 hour. Plates were washed three times. Bound human mAbs were detected using an anti-human IgG HRP-conjugated secondary reagent diluted 1:1000 in PBS containing 1% w/v skim milk powder and 0.1% v/v TWEEN™ 20. Fifty µl/well of the anti-human IgG HRP-conjugated secondary reagent was added to the plates for 1 hour at room temperature. The plates were then washed three times, developed with TMB substrate, and OD read at 450 nm.

Hybridoma Generation. Selected high-responder mice were sacrificed and the spleen and relevant lymph nodes were collected. The fusion of spleen and lymph node cells with the fusion partner SP2/O and subsequent HAT (hypoxanthine/ aminopterin/ thymidine) (GIBCO-BRL, #21060-017) selection of hybridomas were performed according to standard procedures (*Antibodies: A Laboratory Manual*, Harlow and Lane, Cold Spring Harbor Laboratory Press). Briefly, the centrifuge was adjusted to room temperature, with a water bath to 37°C and a heat block to 37°C. Polyethylene glycol (PEG) was warmed to 37°C. Medium was prepared for culturing cells after the fusion was completed. The medium included hybridoma serum-

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free medium (HSFM) (GIBCO-BRL, #12045-084), 5% Ultra low IgG FBS (FBS) (GIBCO-BRL, #16250-078), 2 mM Glutamax-1 (GIBCO-BRL, #35050-061), 50 U/50 μ g/ml Penicillin/Streptomycin (GIBCO-BRL, # 15070-063) and 1x HAT. Media was warmed to 37°C. SP2/O cells were harvested and a viable cell count was performed. The cells were healthy, actively dividing and in log-phase. The viability was >95%. SP2/Os were cultured in HSFM/5% Ultra low IgG FBS prior to fusion, and split 1:2 or 1:3 on the day before the fusion. On the day of fusion, the animals were sacrificed and the spleen (and lymph nodes if required) were immediately removed into sterile medium (Dulbecco's modification of Eagles media (GIBCO-BRL, #11995-073) or DME) on ice. A single-cell suspension was prepared from the spleen, and washed twice (1800 rpm for 7 minutes) in DME, the second wash warm. The SP2/O cells were washed three times (1500 rpm, 7 minutes) with warm DME to remove all traces of serum. SP2/O cells (10^8) were used for one mouse spleen, done as two separate fusions. SP2/Os and spleen cells were pooled together in the same tube and centrifuged at 2100 rpm (400g) for 5 minutes. All DME was removed, leaving only combined pellet. The DME was placed in 37°C heat block. One ml of warm PEG was added drop-wise to the cell pellet over 1 minute whilst stirring the pellet gently with the pipette. Stirring continued gently for another minute. One ml warm DME was added, drop-wise, stirring, over 1 minute. Another 1 ml DME was added over 1 minute. Then 20 ml DME was added over 5 minutes while stirring slowly. This was then centrifuged for 5 minutes at 1500 rpm. All supernatant was removed, and cells were resuspended gently in culture medium as above. One mouse spleen was plated to 5 microtiter plates at 0.2 ml per well in HAT medium. The plates were fed by removing approximately 0.1 ml from each well and replacing with fresh HAT medium every 3 or 4 days. Wells were checked for growth of

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hybridomas at day 7-10 (routine screening 10-14 days after the fusion). Being sure that the medium had not been changed for at least 2-3 days beforehand, ~100 μ l of supernatant was removed from each well for assay. Positives were transferred
5 to 1 ml or 2 ml wells then gradually expanded to 6-well plates. Hybridomas were not clonal at this stage. After 14 days in HAT medium, hybridomas were cultured in HT (GIBCO-BLR, #11067-030) (HSFM, 5% Ultralow IgGFBS, 10 ng/ml rhIL-6 (R&D Systems, #206-IL-050) and HT) for approximately 2 more
10 weeks, then without HT.

Culture of Hybridomas. Hybridomas testing positive at primary and follow-up confirmation ELISA screens were cloned by limit dilution. Limit dilution wells containing single colonies were screened by ELISA and a positive well was
15 selected for expansion. Further rounds of limit dilution cloning were carried out until 100% of wells test positive.

For production of supernatant fluid (SNF) for antibody purification, hybridomas were expanded into either T175 cm² flasks (Falcon, #3028) or roller bottles (900 cm²) (CORNING,
20 #430849). Media used for generation of hybridoma SNFs was HSFM supplemented with 5% Ultralow IgG FBS, 2 mM glutamine and 50 U/50 μ g/ml penicillin/streptomycin. Hybridomas were allowed to grow to confluence and media was harvested by centrifugation approximately 5-10 days later when >90% of
25 cells were dead. All conditioned media was filtered using a STERICUP™ filter apparatus (MILLIPORE, #SCGPU11RE) (0.45 μ m) prior to mAb purification.

Production of Purified mAbs. Monoclonal antibodies were purified from SNF using a standard Protein A affinity
30 chromatography based strategy; see e.g., the following apparatus and reagents. HPLC: AKTA explorer (AMERSHAM Biosciences, Sweden); Column: Protein A (HITRAP™, 1 ml, Amersham Biosciences, Sweden); Buffer A: PBS, 0.02%

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TWEEN™ 20; Buffer B: 0.1 M Glycine pH 2.8; and Buffer C: 2 M Tris pH 8.0.

The column was prepared by washing with 5 volumes of buffer A. Conditioned media was loaded onto dedicated
5 column. A wash was performed with 100 volumes of buffer A, and elution with 20 ml (10X 2 ml) of buffer B. Collection was into tube containing 0.2 ml of buffer C. Column was washed with buffer A to store at 4°C. Desalting was performed using 10K cut-off dialysis membrane into PBS,
10 0.02% TWEEN™ 20. mAb purity was demonstrated by SDS-PAGE with COOMASSIE® Blue staining.

Antibody was quantitated by spectrophotometric analysis at 280 nm using an immunoglobulin extinction coefficient of 1.0 absorbance unit being equivalent to 1.34 mg/ml of
15 antibody.

Example 3: Analysis of Anti-Human IL-13R α 1 Monoclonal Antibody 10G5 Affinity for Human IL-13R α 1

BIACORE™-Based Studies. Human IL-13R α 1.ECR (40 μ g/ml in 20 mM Sodium Acetate, pH 4.2) of Example 1 was immobilized
20 to a sensorchip (CM5, Biosensor, Sweden) using standard NHS/EDC chemistry according to the manufacturer's instructions at a set immobilization value, for example, 1000 RU. Ethanolamine (1.0 M), pH 8.0 was used to quench residual active esters post hIL-13R α 1.ECR immobilization.

25 Analysis of binding of 10G5 (concentration range of 1.4 nM to 150 nM, two-fold dilutions) to the immobilized hIL-13R α 1.ECR was performed in duplicate. Sensorgrams generated were fitted to a bivalent ligand binding model to simultaneously derive association (k_a) and dissociation (k_d)
30 rates and used to determine binding affinity (K_D , Biaevaluation software, BIACORE™, Sweden).

The binding affinity (K_D) of anti-IL-13R α 1 human mAb 10G5 was ~254 pM (n=8).

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Example 4: Analysis of the Binding of Anti-Human IL-13R α 1 Monoclonal Antibody 10G5 To Cynomolgus Macaque And Mouse IL-13R α 1

A cDNA encoding the cynomolgus macaque IL-13R α 1 (cyIL-
5 13R α 1) was cloned by PCR using mRNA extracted from cynomolgus spleen and bone marrow. The mature sequence was highly conserved between cynomolgus and human IL-13R α 1 with an amino acid identity of about 97% (see GENBANK accession No. AAP78901).

10 For production of purified cynomolgus IL-13R α 1.ECR protein, a cDNA encoding cynomolgus IL-13R α 1.ECR (amino acids 9 to 325 of GENBANK accession No. AAP78901 or amino acids 1 to 317 of SEQ ID NO:104) was cloned into the pEFBOS-S-FLAG[®] vector for expression as an N-terminal FLAG[®]-tagged
15 fusion protein essentially as described above for the hIL-13R α 1.ECR.

Mouse IL-13R α 1.ECR (amino acids 27 to 344 of GENBANK accession No. 009030 or amino acids 1 to 318 of SEQ ID NO:105) was also expressed and purified as an N-terminal
20 FLAG[®]-tagged fusion (mIL-13R α 1.ECR) essentially as described above.

The potential cross-reactivity of mAb 10G5 with mouse and cynomolgus IL-13R α 1.ECR was assessed using a BIAcore[™]-based approach. Purified mouse, human and cynomolgus IL-
25 13R α 1.ECR were immobilized individually to three channels of a sensorchip (CM5, BIAcore[™], Sweden) using standard immobilization chemistry. Monoclonal antibodies (concentration range of 312.5 nM down to 125 pM) were assessed for binding to the receptors simultaneously at a
30 flow rate of 15 μ l/minute. Analysis of the affinity of the mAb was performed as described in Example 3 above.

The results of this analysis indicated that MAb 10G5 showed a 10-fold lower affinity (~2.9 nM) for the cynomolgus

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receptor compared with the human receptor (~254 pM), and negligible binding to mouse receptor.

Example 5: Analysis of the Ability of 10G5 to Compete with IL-13 for Binding of Human IL-13R α 1

5 The ability of 10G5 to compete with IL-13 for binding to IL-13R α 1 was assessed by a competition assay on a BIACORE™ instrument. A sensorchip was prepared by immobilizing human IL-13 using standard NHS/EDC chemistry as per the manufacturer's instructions. hIL-13R α 1.ECR protein
10 (8 μ g/mL) was incubated with excess mAb (50 μ g/mL) for 2 hours at room temperature, then injected over the sensorchip. The level of hIL-13R α 1.ECR protein bound to immobilized IL-13 was recorded at a fixed time point within the sensorgram and divided by the corresponding level of
15 hIL-13R α 1.ECR protein bound in the absence of mAb ("relative IL-13 binding"). Binding ratios <1 were indicative of competition between mAb and IL-13 for binding to IL-13R α 1, while values $\geq$ 1 indicated the mAb bound to IL-13R α 1 at a site distinct from that binding IL-13.

20 mAb 10G5 was found to inhibit binding of the hIL-13R α 1.ECR protein to immobilized IL-13.

Example 6: Analysis of the Ability of Anti-Human IL-13R α 1 Monoclonal Antibodies to Antagonize IL-13- and IL-4-Mediated Cellular Responses

25 *Normal Human Dermal Fibroblast (NHDF) Eotaxin Assay.* NHDF cells have been demonstrated to produce eotaxin in response to IL-13 and mAbs directed against the IL-13R α 1 may inhibit this response. Furthermore, NHDF cells were demonstrated not to express the γ c receptor, thus enabling an
30 analysis of the ability of mAbs to inhibit IL-4 activity mediated through the IL-4 Type II receptor, i.e., IL-4R α plus IL-13R α 1. Due to species cross-reactivity, both human

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and non-human primate (e.g., rhesus) IL-13 can be used to stimulate eotaxin production.

NHDF cells (Cambrex, #CC-2509) were cultured in FGM media (Cambrex, #CC3132) supplemented with the recommended additives according to the manufacturer's instructions (complete media). Cells were passaged 1:3 or 1:5 once a week and monitored for responsiveness to IL-13 prior to use. To assess antagonist activity of hIL-13R α 1 specific mAbs, cells were resuspended to 2×10^6 /ml in complete media containing 20 ng/ml PMA (SIGMA, #P8139) and 20 μ g/ml polymyxin (SIGMA, #P4932) and plated in 96-well flat bottom plates (COSTAR, #3595) at 1×10^5 cells/well. Antibody titrations were added to the cells and incubated for 30 minutes, at 37°C with 5% CO₂ in humidified air. Recombinant IL-13 (human or non-human primate) was then added to plates at a final concentration of 30 ng/ml and incubated overnight at 37°C with 5% CO₂ in humidified air. Supernatants were then removed and assayed for eotaxin content by ELISA. For IL-4-induced assays, recombinant IL-4 (PHARMINGEN) was added to plates at a final concentration of 0.5 ng/ml in place of IL-13.

Eotaxin ELISA Protocol. IMMULON®-4 plates (DYNATECH, #3855) were coated with 4 μ g/ml mouse anti-human eotaxin antibody (R&D Systems, MAB320) in PBS (INVITROGEN, #14190-144), overnight at 4°C. Plates were blocked (200 μ l/well, TBS supplemented with 1% BSA and 0.05% TWEEN™ 20) for 1 hour at room temperature and washed three times (wash buffer, TBS plus 0.05% TWEEN™ 20). Test SNF's from the NHDF cells were added at 50 μ l/well and plates were incubated for 2 hours at room temperature, then washed three times. Biotinylated anti-human eotaxin antibody (R&D Systems, BAF320) was added at 200 ng/ml in blocking buffer (60 μ l/well) and incubated for 1 hour at room temperature, then washed three times. Streptavidin-Europium (Wallac, #1244-360) was added at 100 ng/ml in europium buffer (100 μ l/well) and incubated for 20

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minutes at room temperature, then washed three times. Enhancement solution (Wallac, #12244-105) was added, 150 μ l/well, and incubated 1 hour at room temp. Time delayed fluorescence was read using a VICTOR (PERKIN-ELMER) plate
5 reader.

Recombinant human eotaxin (R&D Systems, #320-EO) was used to establish a standard curve. The results of this analysis indicated that the EC_{50} of 10G5 against IL-13 was 0.25 μ g/ml, whereas the EC_{50} against IL-4 was 2.7 μ g/ml.

10 *NHDF IL-13/IL-4-Induced STAT6 Phosphorylation Assay.*
The phosphorylation of STAT6 (pSTAT6) is an essential element of IL-13/IL-4 signal transduction and occurs within minutes of receptor dimerization. IL-13 α 1-specific mAbs may block the phosphorylation of STAT6 in response to IL-13
15 and/or IL-4.

To determine this, 2×10^6 NHDF cells in 50 μ l of RPMI media (#22400-071, INVITROGEN) were plated into 96-well V bottom polypropylene PCR plates (USA Scientific, #1442-9596). Anti-IL-13R mAbs were added to the required
20 concentration in 25 μ l and plates were incubated for 30 minutes at 4°C. Recombinant hIL-13 (100 ng/ml) or hIL-4 (PHARMINGEN, 0.5 ng/ml) was added in 25 μ l and plates were warmed to 37°C in a PCR machine for 20 minutes. After 20 minutes an equal volume of 2X lysis buffer (100 mM HEPES,
25 200 mM NaCl, 2% v/v TRITON® X100, 100 mM NaF, 10 mM DTT, protease inhibitors) was added and pSTAT6 was measured by ELISA.

STAT6 ELISA Protocol. IMMULON®-4 plates (DYNATECH, #3855,) were coated with anti-human phospho STAT6 (BD
30 Transduction Labs, #621995) at 10 μ g/ml in PBS (INVITROGEN, #14290-144) (50 μ l/well) and incubated overnight at 4°C. Plates were blocked (200 μ l/well, TBS supplemented with 1% BSA and 0.05% TWEEN™ 20) for 1 hour at room temperature and

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washed three times (wash buffer, TBS plus 0.05% v/v TWEEN™ 20). Test lysates were added at 50 µl/well and plates were incubated for 2 hours at room temperature, then washed three times. Biotin anti-STAT6 (BD Transduction Labs, #621141, 5 conjugated to biotin, 20:1 molar ratio) was added at 2 µg/ml in blocking buffer (60 µl/well) and incubated for 1 hour at room temperature, then washed three times. Streptavidin-Europium (Wallac, #1244-360) was added at 100 ng/ml in europium buffer (100 µl/well) and incubated for 20 minutes 10 at room temperature, then washed three times. Enhancement solution (Wallac, #12244-105) was added (150 µl/well) and incubated 1 hour at room temperature. Time-delayed fluorescence was read using a VICTOR (PERKIN-ELMER) plate reader.

15 The results of this analysis indicated that the EC₅₀ of 10G5 was 1.0 µg/ml against IL-13, whereas the EC₅₀ against IL-4 was 1.3 µg/ml.

Example 7: Cloning and Sequencing of the 10G5 Murine Antibody Variable Regions

20 Messenger RNA was prepared from hybridoma cells producing antibody 10G5 and reverse-transcribed using an oligo-dT primer to produce cDNA. Several independent PCR reactions were performed. The PCR reactions were performed at the following conditions: 94°C for 2 minutes; 30 cycles of 25 94°C for 30 seconds, 60°C for 30 seconds and 68°C for 1 minute; and 68°C for 10 minutes. Two alternative PCR conditions were also developed in cloning antibody genes: 1) 94°C for 2 minutes; 30 cycles of 94°C for 30 seconds, 68°C for 30 seconds, and 68°C for 1 minute; and 68°C for 10 30 minute; and 2) 30 cycles of 94°C for 1 minute, 55°C for 1 minute, and 72°C for 1 minute. PCR amplicons were separated on 1.2% agarose gels. In terms of the heavy chain variable region, the following primer sets yielded a PCR product. For the 5' end of the heavy chain variable region, the primers

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were VH5, 5'-G GGG TCA ACC GCC ATC CTY G-3' (SEQ ID NO:114), wherein Y was C or T (Degen 2); and VH6, 5'-GTC TCC TTC CTC ATC TTC CTG CCC-3' (SEQ ID NO:115) (Degen 1); while the primer for the 3' end of V_H was HA, 5'-C CCA TCG GTC TTC CCC
5 CTG GCA C-3' (SEQ ID NO:116). In terms of the light chain variable region, four primer sets yielded a PCR product. The PCR products were cloned in plasmid TOPO® pCK2.1 (INVITROGEN). Sequence analysis of the heavy chain clone had the best match to germline, VH5-51. For the light chain
10 variable region, the primers for the 5' end that yielded a sequence with the best match to germline, VL VKIII A27, were VK3, 5'-YTC TTC CTC CTG CTA CTC TGG CTC-3' (SEQ ID NO:117), wherein Y was C/T (Degen 2); and VK4, 5'-ATG GTG TTG CAG ACC CAG GTC TTC-3' (SEQ ID NO:118) (Degen 1); while the primer
15 for the 3' end of V_L was KA, 5'-G AAA TCT GGA ACT GCC TCT GTT GTG TGC CTG C-3' (SEQ ID NO:119).

The initially identified nucleotide and amino acid sequences containing the heavy and light chain variable regions of 10G5 included both leader and some additional
20 downstream sequence (see, SEQ ID NOS:42 and 44 for the heavy chain, and SEQ ID NOS:46 and 48 for the light chain). The nucleotide and amino acid sequences of the heavy chain variable region of 10G5 are shown in Figure 1 and in SEQ ID NOS:43 and 45, respectively. The nucleotide and amino acid
25 sequences of the light chain variable region of 10G5 are shown in Figure 2 and in SEQ ID NOS:47 and 49, respectively.

Example 8: Analysis of mAb Binding to Phage Displayed Human IL-13R α 1 Peptides

Mutation of the phenylalanine at position 233 of the
30 amino acid sequence of human IL-13R α 1 extracellular region to alanine effected a significant decrease in binding of antibody 10G5 as compared to binding of the antibody to wild-type human IL-13R α 1 extracellular region. Accordingly, Phe233 was identified as an important residue on the

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receptor for binding of antibody 10G5. Conveniently, the human IL-13R α 1 extracellular region or the corresponding Phe233Ala mutant were fused via the C-terminus to a fragment of the gene 3 protein (amino acids 249-406) generally in accordance with the procedure described by Lowman *et al.*, 1991 *Biochem.* 30:10832-10838. These IL-13R α 1-derived peptides were then displayed on M13 bacteriophage and assayed by ELISA for binding to immobilized 10G5 or 1D9. Briefly, mAbs were passively adsorbed onto 96-well MAXISORP™ plates (NUNC) following overnight incubation of 100 μ l/well of 2.5 μ g/mL mAb diluted in PBS buffer. Coating solutions were discarded, plates were blocked by incubation with blocking buffer for 1 hour at room temperature, then washed once with wash buffer. Phage samples serially diluted with 1% w/v skim milk powder in PBS (diluting buffer) were then transferred into mAb-coated plates (100 μ L/well). Following incubation at room temperature for 2 hours, plates were washed 3 times, and bound phage labeled with anti-M13 IgG HRP-conjugated polyclonal antibody, and detected by addition of TMB substrate. TMB color development was quenched by addition of 2 M aqueous sulfuric acid, and absorbance at 450 nm was measured.

Example 9: Antibody Identification

Methods. The variable heavy and the variable light sequences of antibody 10G5 (SEQ ID NOs:43 and 47, respectively) were cloned in a Fab phage-display vector, pFab3d (Figures 3, 4A, and 4B) with a 1929 bp *Xho*I/*Apa*I fragment from the *PKS3* locus of the fungus *Glarea lozoyensis* cloned at the *Xho*I/*Apa*I site as a stuffer in the light chain construct, then randomly mutated in the variable heavy and light CDR3 regions (each library possessing $\geq 10^8$ functional diversity). The resultant mutants were then panned against biotinylated human and primate (rhesus and cynomolgous monkey) IL-13R α 1 in solution using standard phage display

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protocols (see, e.g., *Phage Display: A Laboratory Manual*, 2001, Cold Spring Harbor Laboratory Press). Human and primate sequences have been disclosed in the literature; see, e.g., GENBANK Accession Nos. U62858, CAA70508, and
5 AAP78901. By lowering the concentration of target in each subsequent round of panning (e.g., 10 nM, 1 nM, 0.1 nM, and 0.01 nM), the stringency of panning was effectively increased, thereby enriching for higher and higher affinity phage with each subsequent round. Phage ELISA was used as
10 the primary assay to determine the ability of the phage-bound recombinant Fabs to recognize the biotinylated IL-13R α 1 immobilized on streptavidin plates (see, e.g., *Phage Display: A Laboratory Manual*, *supra*). Myc-capture ELISA and dissociation assays (general protocols described herein)
15 were used as secondary screening tools. BIACORE™ surface plasmon resonance and KINEXA™ kinetic exclusion assays were performed to characterize the binding kinetics of the antibodies identified. These assays were performed in accordance with the published manufacturers' protocols.
20 Specific antibodies were converted into full-length antibodies of subclass IgG4 for expression, production and characterization in mammalian cells (general protocol described below).

Myc Capture and Dissociation Assays. Two assays are run
25 in parallel. The first (I) measured the amount of antibody captured from peripreps. This assured that data was collected only from wells that had sufficient and equivalent amounts of antibody. The second (II) measured the dissociation of IL-13 receptor from the plate-bound
30 antibody.

Assay (I): IMMULON®-4 plates (DYNATECH, #3855) were coated with polyclonal anti-human kappa antibody (Immunology Consultants Lab, #GKBF-80A-K116) at 5 µg/ml in PBS (INVITROGEN, #14290-144) (50 µl/well) and incubated

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overnight at 4°C. Blocking buffer (200 µl/well) was added and the plates were incubated for 1 hour at room temperature. The plates were washed three times with wash buffer. Neat periprep was added, 50 µl/well, and left for 2 hours at room temperature. The plates were washed three times with wash buffer. Fifty µg/ml of human gamma globulin (Pierce, #31879) was added in block buffer and left to incubate overnight at 4°C. The plates were washed three times with wash buffer in the morning and afternoon followed by the addition of 150 µl/well of block buffer while incubating at 37°C throughout. The plates were washed three times with wash buffer. Bound antibody was detected with biotin anti-Myc (Upstate, #16-212) at 1 µg/ml in blocking buffer (60 µl/well) for 1 hour at room temperature. The plates were washed three times with wash buffer. Streptavidin-europium (Wallac, #1244-360) was added at 100 ng/ml in Europium buffer (100 µl/well) for 20 minutes at room temperature. A final wash step (three times) was performed and enhancement solution (Wallac, #1244-105) at 150 µl/well was added for 1 hour at room temperature. Plates were read by time-delayed fluorescence on a VICTOR (PERKIN-ELMER) plate reader.

Assay (II): IMMULON®-4 plates (DYNATECH, #3855) were coated with polyclonal anti-human kappa antibody (Immunology Consultants Lab, #GKBF-80A-K116) at 5 µg/ml in PBS (INVITROGEN, #14290-144) (50 µl/well) and incubated overnight at 4°C. Blocking buffer (200 µl/well) was added and the plates were incubated for 1 hour at room temperature. The plates were washed three times with wash buffer. Neat periprep was added, 50 µl/well, and left for 2 hours at room temperature. The plates were washed three times with wash buffer. Sixty µl/ml of 400 ng/ml FLAG®-tagged human IL13 receptor was added with 50 µg/ml of human gamma globulin (Pierce, #31879) in block buffer and left to incubate

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overnight at 4°C. The plates were washed three times with wash buffer at two, six-hour intervals followed by the addition of 150 µl/well of block buffer. Incubations were carried out at 37°C. The plates were washed three times with wash buffer. Residual IL-13 receptor was detected with biotin anti-FLAG® (IBI, #3081/6H2411) at 1 µg/ml in blocking buffer (60 µl/well) for 1 hour at room temperature. The plates were washed three times with wash buffer. Streptavidin-europium (Wallac, #1244-360) was added at 100 ng/ml in Europium buffer (100 µl/well) for 20 minutes at room temperature. A final wash step (three times) was performed and enhancement solution (Wallac, #1244-105), 150 µl/well, was added for 1 hour at room temperature. Plates were read by time-delayed fluorescence on a Victor (Perkin-Elmer) plate reader.

Conversion to Full-Length IgGs. Anti-IL13Rα1 monoclonal antibodies were converted into whole antibody of subclass IgG4 for expression and production in mammalian cells. Their variable regions were PCR-amplified from the corresponding Fab vectors and in-frame cloned into a LONZA pCON antibody expression vector with leader sequences in front of the antibody sequences. In the vector, genomic DNA sequences for all constant regions for light and heavy chains were already engineered in the vectors. The expression is driven by a human cytomegalovirus (CMV) early promoter and followed by an SV40 polyadenylation signal. The plasmids have bacterial sequence for plasmid replication and ampicillin selection marker and the plasmid for the light chain, pCONKAPPA, has the GS gene for glutamine synthetase as a selection marker in mammalian cells. In-frame fusion of variable regions allows the proper expression of whole antibody. By design, leader sequences from mouse light and heavy chains were included in front of the antibody open reading frames. A

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consensus Kozak sequence (*italics only*) was also included surrounding the ATG start codon to improve protein expression level. Forward and reverse primers were designed for PCR amplification of four variable regions. For 10G5

5 light chain variable region, forward primer, 5'-ATC GAA GCT
TGC CGC CAC CAT GAG TGT GCC CAC TCA GGT CCT GGG GTT GCT GCT
GCT GTG GCT TAC AGA TGC CAG ATG TGA AAT TGT GTT GAC GCA GTC
T-3' (SEQ ID NO:88) and reverse primer, 5'-CCA CCG TAC GTT
TGA TTT CCA C-3' (SEQ ID NO:89) were employed. For 10G5

10 heavy chain variable region, forward primer, 5'-ACT GAA GCT
TGC CGC CAC CAT GGA ATG GAG CTG GGT CTT TCT CTT CTT CCT GTC
AGT AAC TAC AGG TGT CCA CTC CGA GGT GCA GCT GGT GCA GTC T-3'
(SEQ ID NO:90) and reverse primer, 5'-ACC GAT GGG CCC TTG
GTG GAG GCT-3' (SEQ ID NO:91) were employed. The leader

15 sequences are in bold and underlined and the cloning sites
(*Hind*III in the forward primers for both light and heavy
chains, in the reverse primers, *Bsi*WI for the light chain
and *Apa*I for the heavy chain) are given in underlining and
italics.

20 The variable regions were PCR-amplified for 20 cycles
using these pairs of primers and Fab vectors carrying 10G5
variable region sequences. PCR products were digested with
*Hind*III and *Bsi*WI for light chains and *Hind*III and *Apa*I for
heavy chains. Enzyme-digested PCR fragments were cloned into

25 Lonza's vectors (pCONKAPPA for light chain and pCONGAMMA4
for heavy chain). The entire expression cassette of
respective heavy chain from pCONGAMMA4 vectors digested with
*Not*I and *Sal*I was then inserted into the corresponding light
chain vector digested with the same enzymes. The entire open

30 reading frames for both light chain and heavy chain were
verified by DNA sequence analysis.

Antibody Expression, Purification and Characterization.
Either combined light chain and heavy chain plasmid DNA or a
1:1 ratio mixture of corresponding light and heavy chain

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plasmid DNA were transfected in 293-derived cell lines. For pCON vectors, 293 FREESTYLE™ suspension cell line from INVITROGEN was used along with its transfection reagents. For 200 ml of 293 FREESTYLE™ cells, 100 µg each of heavy and light chain plasmid DNA and 300 µl of reagents were used for transfection. The transfected cells were incubated at 37°C/5% CO₂ for 7-8 days before harvest. Culture medium was harvested, filtered and concentrated using by low speed MILLIPORE CENTRICON® centrifugation (concentrator, MILLIPORE).

Results. ELISA analyses are presented in Figures 5-8. In Figures 5-7, the mutants significantly distinguished by their activity were 10G5H6 (VHCDR3: SEQ ID NO:5; VLCDR3: SEQ ID NO:41); 10G5H5 (VHCDR3: SEQ ID NO:4; VLCDR3: SEQ ID NO:41); 10G5H11 (VHCDR3: SEQ ID NO:3; VLCDR3: SEQ ID NO:41); and 10G5H33 (VHCDR3: SEQ ID NO:25 (involving a The=>Ile residue change in the third to last amino acid residue therein); VLCDR3: SEQ ID NO:41). Figure 8 illustrates ten mutants highlighted as functioning more effectively than 10G5H6. The mutants tested in Figure 8 have EC₅₀ values and possess the heavy and light CDR3 regions as listed in Table 4.

TABLE 4

Antibody	VHCDR3	VLCDR3	EC ₅₀ (µM)
SJ2-66	SEQ ID NO:5	SEQ ID NO:28	1.757
10G5H6	SEQ ID NO:5	SEQ ID NO:41	1.636
SJ2-88	SEQ ID NO:5	SEQ ID NO:27	1.536
SJ3-50	SEQ ID NO:5	SEQ ID NO:29	1.341
SJ2-74	SEQ ID NO:5	SEQ ID NO:32	1.308
SJ2-63	SEQ ID NO:5	SEQ ID NO:33	1.248
SJ3-68	SEQ ID NO:5	SEQ ID NO:34	1.24
SJ3-71	SEQ ID NO:5	SEQ ID NO:35	1.186
SJ2-57	SEQ ID NO:5	SEQ ID NO:36	1.14

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SJ2-85	SEQ ID NO:5	SEQ ID NO:37	1.123
SJ2-81	SEQ ID NO:5	SEQ ID NO:38	0.9334

KINEXA[®] analyses were performed on select antibodies. The data for specific full-length antibodies is illustrated in the Tables 5 and 6 containing data from two different experiments.

TABLE 5

Antibody	VHCDR3	VLCDR3	K _D
10G5-1	SEQ ID NO:5	SEQ ID NO:38	54.84 pM
10G5-2	SEQ ID NO:22	SEQ ID NO:38	45.44 pM
10G5-4	SEQ ID NO:23	SEQ ID NO:38	66.93 pM

TABLE 6

Antibody	VHCDR3	VLCDR3	K _D
10G5 WT	SEQ ID NO:40	SEQ ID NO:41	861 pM
10G5H6	SEQ ID NO:5	SEQ ID NO:41	99.43 pM
10G5-2	SEQ ID NO:22	SEQ ID NO:38	31.44 pM
10G5-4	SEQ ID NO:23	SEQ ID NO:38	20.35 pM
10G5-6	SEQ ID NO:7	SEQ IDNO: 38	26.8 pM

BIACORE[™] analyses were performed on various antibodies in Fab format. Tables 7 and 8 illustrate data from two different experiments:

TABLE 7

Antibody	VHCDR3	VLCDR3	K _D
10G5 WT	SEQ ID NO:40	SEQ ID NO:41	4.5 nM
10G5H6	SEQ ID NO:5	SEQ ID NO:41	0.6 nM

TABLE 8

Antibody	VHCDR3	VLCDR3	K _D
10G5 WT	SEQ ID NO:40	SEQ ID NO:41	1.35 nM
10G5H11	SEQ ID NO:3	SEQ ID NO:41	106 pM

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10G5R4-10	SEQ ID NO:15	SEQ ID NO:41	196 pM
10G5R4-11	SEQ ID NO:16	SEQ ID NO:41	233 pM
10G5R4-2A	SEQ ID NO:7	SEQ ID NO:41	817 pM
10G5R4-2B	SEQ ID NO:23	SEQ ID NO:41	116 pM
10G5SJ2-81	SEQ ID NO:5	SEQ ID NO:38	43 pM

The data provided illustrate that antibodies could be identified, through the various screens and analyses conducted, with significantly enhanced affinity for IL-
5 13R α 1. The antibodies uncovered demonstrated quite frequently a general consensus in their sequence. More specifically, it was concluded from these studies that (1) three residues in the heavy chain variable region CDR3 domain were more apt to positively effect function upon
10 mutation, namely, residues 1, 7 and 9 of SEQ ID NO:40, and (2) three residues in the light chain variable region CDR3 domain were more apt to positively effect function upon mutation, namely, residues 2, 4 and 5 in SEQ ID NO:41.

Antibodies with a manipulated Fc region were also
15 developed. The manipulations in the Fc region allowed for an antibody that exhibits reduced binding to Fc γ R receptors or C1q. Binding to FcRn (also known as the neonatal receptor or Brambell receptor) is not substantially modified nor is the antibody half-life. The purpose of the modifications was to
20 generate antibodies that do not provoke (or provoke to a lesser extent) antibody-dependent cellular cytotoxicity (ADCC), complement-mediated cytotoxicity (CMC), or form immune complexes, while retaining normal pharmacokinetic (PK) properties. As will be acknowledged by the skilled
25 artisan, the disclosed human antibody IgG structure (that encompasses SEQ ID NO:92) can be used in conjunction with any variety of V_H and V_L sequences disclosed herein, with the appropriate C_k or C _{λ} , in the development of full-length antibodies.

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KINEXA[®] analyses were performed on select antibodies with the manipulated Fc. Amino acid and nucleotide sequences for 10G5-6 in the manipulated IgG format are set forth in SEQ ID NOs:94 and 95, respectively. Table 9 summarizes data
 5 obtained for select full-length antibodies upon 2-curve K_d analysis using KINEXA[®].

TABLE 9

Antibody	VHCDR3	VLCDR3	K_D
10G5-6 IgG4	SEQ ID NO:7	SEQ IDNO: 38	44.36 pM
10G5-6 IgG2m4	SEQ ID NO:7	SEQ IDNO: 38	30.79 pM
10G5 WT IgG2m4	SEQ ID NO:40	SEQ ID NO:41	2.06 nM
10G5H6 IgG2m4	SEQ ID NO:5	SEQ ID NO:41	94.64 pM

Antibodies manipulated in this manner have been found
 10 to exhibit several advantages over the native IgG isotypes. The first is that they do not bind Clq as strongly as IgG2, rendering it less effective in activating the complement cascade. The manipulated antibodies also do not bind, or exhibit significantly reduced binding, to Fc γ receptors at
 15 physiologically relevant levels, in particular Fc γ RI, which eliminates (or significantly reduces) any undesired NK-cell or T-cell activation; significantly impedes the antibody's ability to mediate ADCC; and eliminates (or significantly reduces) a potential alternative sink for the antibody *in*
 20 *vivo*. The resultant antibodies also retain the half-life and basic structure of an IgG2, which is highly desirable. The blood half-life of 10G5-6 IgG2m4 was found in a separate study to be in the order of 306 hours when tested in SCID mice. This half-life is comparable with the numbers reported
 25 for IgG2; see, e.g., Zuckier et al., 1994 *Cancer Suppl.* 73:794-799.

Example 10: Functional Studies - Eotaxin Release

NHDF Eotaxin Release Assay. NHDF cells were purchased from Cambrex (#CC-2509) and were cultured in FGM media

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(Cambrex, #CC-3132) supplemented with additives provided, referred to below as complete media. Cells were passaged 1:3 or 1:5 once a week and were monitored for responsiveness to IL-13 prior to use. To assess antagonistic activity of IL-13R α 1 antibodies, cells were resuspended to 2×10^6 /ml in complete media containing 20 ng/ml PMA (SIGMA, #P8139) and 20 μ g/ml polymyxin (SIGMA, #P4932) and plated in 96-well flat bottom plates (COSTAR, #3595) at 1×10^5 cell/well. Antibody titrations were added to the cells and incubated for 30 minutes at 37°C in a 5% CO₂ incubator. Recombinant rhesus IL-13 or recombinant human IL4 (BD PHARMINGEN, #554605) was then used at the respective EC₅₀ for each cytokine and incubated overnight at 37°C in a 5% CO₂ incubator. Supernatants were removed and assayed for eotaxin content by immunoassay. Briefly, IMMULON®-4 plates (DYNATECH, #3855) were coated with 2 μ g/ml anti-human eotaxin antibody (PHARMINGEN, #555035) in PBS (INVITROGEN, #14190-144) overnight at 4°C. The plates were blocked with blocking buffer for 1 hour at room temperature and washed three times with wash buffer. Supernatants from the NHDF cells were added to the plates along with a recombinant human eotaxin standard (R&D Systems, #320-EO). The samples were captured for 2 hours at room temperature, washed and biotinylated anti-human Eotaxin detection antibody (PHARMINGEN, #555060) was added at 200 ng/ml for 1 hour at room temperature. Plates were washed and streptavidin-europium (Wallac, #1244-360) was added at a concentration of 100 ng/ml for 20 minutes at room temperature. A final wash step was performed and enhancement solution (Wallac, # 1244-105) was added for 1 hour at room temperature. Plates were read by time-delayed fluorescence on a VICTOR (PERKIN-ELMER) plate reader.

Results. Eotaxin release from normal human dermal fibroblast (NHDF) cells upon contact with IL-13R α 1-specific

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antibodies was analyzed. The assays were carried out using either IL-13 and/or IL-4 as a stimulant. When IL-13 was used as the inducing agent, the optimized antibodies were at least 2-fold more potent in these types of assays than the parental form, 10G5. An example of the fold-difference in functioning is illustrated in Figure 9, where IC₅₀ values for 10G5, 10G5H6, and 10G5-6 were determined to be 310 ng/mL (~2 nM), 110 ng/mL (~730 pM), and 70 ng/mL (~467 pM), respectively, with IL-13 as the stimulant. Figure 10 illustrates antibody inhibition of the formation of eotaxin by NHDF cells where IL-4 is used as the stimulant. An experiment was performed with a number of full-length antibodies of the present description. Data concerning inhibition of eotaxin release from NHDF cells upon stimulation by IL-13 is summarized in Table 10.

TABLE 10

Antibody	VHCDR3	VLCDR3	EC ₅₀
10G5 WT	SEQ ID NO:40	SEQ ID NO:41	2.309 µg/ml
10G5-1	SEQ ID NO:5	SEQ ID NO:38	0.497 µg/ml
10G5-2	SEQ ID NO:22	SEQ ID NO:38	0.456 µg/ml
10G5-3	SEQ ID NO:5	SEQ ID NO:39	0.614 µg/ml
10G5-4	SEQ ID NO:23	SEQ ID NO:38	0.330 µg/ml
10G5-5	SEQ ID NO:23	SEQ ID NO:41	0.939 µg/ml
10G5H6	SEQ ID NO:5	SEQ ID NO:41	0.474 µg/ml

Data concerning inhibition of eotaxin release from NHDF cells upon stimulation by IL-4 is summarized in Table 11.

TABLE 11

Antibody	VHCDR3	VLCDR3	EC ₅₀
10G5 WT	SEQ ID NO:40	SEQ ID NO:41	4.533 µg/ml
10G5-1	SEQ ID NO:5	SEQ ID NO:38	0.907 µg/ml
10G5-2	SEQ ID NO:22	SEQ ID NO:38	0.730 µg/ml

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10G5-3	SEQ ID NO:5	SEQ ID NO:39	0.983 µg/ml
10G5-4	SEQ ID NO:23	SEQ ID NO:38	0.660 µg/ml
10G5-5	SEQ ID NO:23	SEQ ID NO:41	2.267 µg/ml
10G5H6	SEQ ID NO:5	SEQ ID NO:41	1.438 µg/ml

Example 11: Functional Studies - STAT6 Phosphorylation:

NHDF STAT6 Phosphorylation Assay. NHDF cells were purchased from Cambrex (#CC-2509) and were cultured in FGM media (Cambrex, #CC-3132) supplemented with additives provided. Plate NHDF cells at 2e6/ml in 50 µl volume in 96-well V-bottom polypropylene PCR plates (USA Scientific, #1442-9596) in RPMI Media (INVITROGEN, # 22400-071). Anti-IL-13R antibodies were added in 25 µl volume and incubated for 30 minutes at 4°C. Recombinant rhesus IL-13 or recombinant human IL-4 (PHARMINGEN) was added in 25 µl volume. The plates were warmed to 37°C in PCR machine for 20 minutes and, immediately, equal volume of 2X lysis buffer (100 µl) was added. pSTAT6 was measured by immunoassay. IMMULON®-4 plates (DYNATECH, #3855) were coated with anti-human phospho STAT6 (BD Transduction Labs, 621995) at 10 µg/ml in PBS (INVITROGEN, #14290-144,) (50 µl/well) overnight at 4°C. Blocking buffer (200 µl/well) was added for 1 hour at room temperature. The plates were washed three times with wash buffer. Fifty µl/well lysate was added and incubated for 2 hours at room temperature. The plates were washed three times with wash buffer. Detection was enabled with biotin anti-STAT6 (BD Transduction Labs, conjugated 20:1 molar ratio) at 2 µg/ml in blocking buffer (60 µl/well) added for 1 hour at room temperature. The plates were washed three times with wash buffer. Streptavidin-Europium (Wallac, #1244-360) at 100 ng/ml was added in europium buffer (100 µl/well) for 20 minutes at room temperature. The plates were washed three times with wash buffer. Enhancement solution

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(Wallac, #12244-105) was added (150 μ l/well) for 1 hour at room temperature, and plates were read by time-delayed fluorescence on a VICTOR (PERKIN-ELMER) reader.

Results. Antibody inhibition of IL-13- and IL-4-induced
5 STAT6 phosphorylation was studied in NHDF cells. When IL-13 was used as the inducing agent, the optimized antibodies were at least 3-fold more potent in these types of assays than the parental form, 10G5. An example of the fold-difference in functioning is illustrated in Figure 11, where
10 the EC₅₀s for 10G5 and 10G5H6 were determined to be 2.9 μ g/ml and 0.8 μ g/ml, respectively, with IL-13 as the stimulant. Figure 12 illustrates antibody inhibition of STAT6 phosphorylation in NHDF cells, where IL-4 is used as the stimulant. Results of this analysis indicated EC₅₀s of 5.0
15 μ g/ml and 1.8 μ g/ml for 10G5 and 10G5H6, respectively.

Example 12: Functional Studies - TARC Release

Thymus and Activation-Regulated Chemokine (TARC) Release Assay (Dog, Rhesus or Human). Blood was collected in heparinized VACUTAINER® tubes (VWR, VT6480). PBMCs were
20 isolated over Lymphocyte Separation Media (ICN, 50494X). PBMCs or whole blood was plated in 96-well flat bottom plates (COSTAR, #2595). Antibodies were added and incubated for 30 minutes at room temperature. Recombinant rhesus IL-13 was added at 10 ng/ml final concentration and incubated for
25 24-72 hours at 37°C with CO₂ in a humidified chamber. Supernate or plasma was collected (TARC can be detected as early as 24 hours but levels continue to increase). TARC was measured by immunoassay. IMMULON®-4 plates (DYNATECH, 3855) were coated with anti-human TARC (R&D, #AF364) at 2 μ g/ml in
30 PBS (INVITROGEN, #14290-144), 50 μ l/well. The plates were incubated overnight at 4°C. Blocking buffer (200 μ l/well) was added and incubated for 1 hour at room temperature. The plates were washed three times with wash buffer. Plasma or

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supernate was added, 50 μ l/well, and incubated for 2 hours at room temperature (plasma diluted 1:2). A standard curve was included starting at 20 ng/ml recombinant human TARC diluted 2-fold. The plates were washed three times with wash
5 buffer. Detection was carried out with biotin anti-human TARC (RDI, #RDI-TarcabrP1, conjugated to biotin 20:1 molar ratio) at 250 ng/ml in blocking buffer (60 μ l/well) for 1 hour at room temperature. The plates were washed three times with wash buffer. Streptavidin-Europium (Wallac, #1244-360)
10 was added 100 μ l/well at 100 ng/ml in europium buffer for 20 minutes at room temperature. The plates were washed three times with wash buffer. Enhancement solution (Wallac, #12244-105), 150 μ l/well, was added and incubated for 1 hour at room temperature. Time-delayed fluorescence was read in a
15 VICTOR (PERKIN-ELMER) reader.

Results. The effect of the present antibodies on TARC release following stimulation with 10 ng/mL of IL-13 was examined. Figure 13 illustrates, for example, the ability of 10G5-6 to block the IL-13-stimulated release of TARC (CCL17)
20 in whole human blood. The antibody yielded an IC_{50} of ~112 ng/mL, 746 pM. Figure 14 illustrates functioning of another antibody, 10G5H6, versus 10G5 WT (wild-type) in an IL-13-stimulated TARC release assay from whole human blood. Figure 15 illustrates the effect of 10G5-6 alongside 10G5H6 in
25 blocking the release of TARC after stimulation of whole rhesus blood with rhesus IL-13.

Example 13: Functional Studies - Inhibition of Cell Proliferation of Hodgkin's Disease:

Methods. 10G5, 10G5H6 and 10G5-6 were assayed to
30 determine whether the antibodies were effective in inhibiting cell proliferation of Hodgkin's disease cell line L1236. Hodgkin's and Reed-Sternberg cells have been studied previously with regard to the cytokine IL-13; see, e.g., Kapp et al., 1999 *J. Exp. Med.* 189:1939-1945; Skinnider et

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al., 2001 *Blood* 97:250-255; Skinnider et al., 2002 *Blood* 99:618-626; and in U.S. Patent No. 6,468,528, and the methods of analyzing same are discussed therein.

5 *Results.* In this assay, 10G5 gave an IC_{50} of about 300 ng/mL (2 nM), whereas both 10G5H6 and 10G5-6 yielded IC_{50} s of about 50 ng/ml (~330 pM) which for both represented a ca. 6-fold improvement over that of the parent 10G5 IgG. See Figure 17.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An isolated antibody that binds to human interleukin 13 receptor alpha 1, wherein
 - 5 (a) the heavy chain variable region of said antibody comprises CDR1, CDR2, and CDR3 amino acid sequences as set forth in SEQ ID NO:82, SEQ ID NO:83, and SEQ ID NO:121, respectively; and
 - (b) the light chain variable region of said antibody comprises CDR1, CDR2, and CDR3 amino acid sequences as set forth in SEQ ID NO:84, SEQ ID NO:85, and
10 SEQ ID NO:122, respectively.
2. The isolated antibody of claim 1, further comprising a heavy chain constant region as set forth in SEQ ID NO:92.
- 15 3. An isolated antibody that binds to human interleukin 13 receptor alpha 1 comprising
 - (a) a heavy chain variable region having an amino acid sequence selected from the group consisting of SEQ ID NO:45, SEQ ID NO:51, SEQ ID NO:55, SEQ ID NO:59, SEQ ID NO:63 and SEQ ID NO:67;
 - 20 (b) a light chain variable region having an amino acids sequence selected from the group consisting of SEQ ID NO:49, SEQ ID NO:71, SEQ ID NO:75 and SEQ ID NO:79; or
 - (c) a combination of (a) and (b).
- 25 4. The isolated antibody of claim 3, wherein said antibody is produced by the hybridoma cell line deposited as ATCC Deposit No. PTA-6933.
5. The isolated antibody of claim 3, further comprising a heavy chain constant region as set forth in SEQ ID NO:92.
- 30 6. The isolated antibody of claim 5, wherein the heavy chain variable region has an amino acid sequence as set forth in SEQ ID NO:63 and the light chain variable region has an amino acid sequence as set forth in SEQ ID NO:71.

7. An isolated antibody that exhibits an equilibrium dissociation constant (K_D) of less than 200 pM with human interleukin 13 receptor alpha 1 and antagonizes human interleukin 13 receptor alpha 1-mediated activity, wherein

5 (a) the heavy chain variable region of said antibody comprises an amino acid sequence as set forth in SEQ ID NO:63 or a sequence at least 90% homologous to the sequence set forth in SEQ ID NO:63; and

(b) a light chain variable region of said antibody comprises an amino acid sequence as set forth in SEQ ID NO:71 or a sequence at least 90% homologous to the sequence set forth in SEQ ID NO:71.

10

8. The isolated antibody of claim 7, wherein the antibody is further characterized by exhibiting significantly reduced binding to a polypeptide having an amino acid sequence as set forth in SEQ ID NO:120 relative to its binding to a polypeptide having an amino acid having sequence as set forth in SEQ ID NO:101.

15

9. The isolated antibody of claim 7 or claim 8, further comprising a heavy chain constant region as set forth in SEQ ID NO:92.

10. A composition comprising the antibody of any one of claims 1 to 9 and a
20 pharmaceutically acceptable carrier.

11. A method for ameliorating a condition caused or exacerbated by interleukin 13 receptor alpha 1-mediated activity comprising administering to a subject in need of treatment an effective amount of the composition of claim 10 thereby ameliorating the
25 condition caused or exacerbated by interleukin 13 receptor alpha 1-mediated activity.

12. The method of claim 11, wherein the condition is asthma, allergy, allergic rhinitis, chronic sinusitis, hay fever, atopic dermatitis, chronic obstructive pulmonary disease, pulmonary fibrosis, esophageal eosinophilia, scleroderma, psoriasis, psoriatic
30 arthritis, fibrosis, inflammatory bowel disease, ulcerative colitis, anaphylaxis, or cancer.

13. The method of claim 12, wherein the cancer is Hodgkin's lymphoma, glioma, or renal carcinoma.

35

14. An isolated nucleic acid which encodes a variable region of an antibody that binds to human interleukin 13 receptor alpha 1, wherein the variable region comprises
- a) a heavy chain variable region having an amino acid sequence selected from the group consisting of SEQ ID NO:45, SEQ ID NO:51, SEQ ID NO:55, SEQ ID NO:59, SEQ ID NO:63 and SEQ ID NO:67; or
- b) a light chain variable region having an amino acid sequence selected from the group consisting of SEQ ID NO:49, SEQ ID NO:71, SEQ ID NO:75 and SEQ ID NO:79.
15. A vector comprising the nucleic acid of claim 14.
16. An isolated host cell comprising the nucleic acid of claim 14 or the vector of claim 15.
17. Use of the antibody according to any one of claims 1 to 9, or the composition of claim 10, for the manufacture of a medicament for ameliorating a condition caused or exacerbated by interleukin 13 receptor alpha 1-mediated activity in a subject.
18. An isolated antibody, or isolated nucleic acid encoding said antibody, that binds to human interleukin 13 receptor alpha 1 substantially as hereinbefore described with reference to the Examples, excluding the comparative Examples.

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GAGGTGCAGCTGGTGCAGTCTGGAGCAGAGGTGAAAAGCCCGGGAGTCTCTGAAGATCTCCTGT
 E V Q L V Q S G A E V K K P G E S L K I S C

 AAGGTTCTGGATACAGCTTTACCAGCTACTGGATCGGCTGGTGCGCCAGATGCCCGGAAAGGC
 K G S G Y S F T S Y W I G W V R Q M P G K G
 CDR1
 CTGGAGTGGATGGGGTCACTATCCTGGTGACTCTTATACCAAGATACAGCCCGTCCCTCCAAAGC
 L E W M G V I Y P G D S Y T R Y S P S F Q G
 CDR2
 CAGGTCACCATCTCAGCCGACAAAGTCCATCAGCACCGCCTACCTGCAGTGGAGCAGCCCTGAAGGCC
 Q V T I S A D K S I S T A Y L Q W S S L K A
 TCGGACACCGCCATGTATTACTGTGCGAGATTCCCCAACTGGGGCTCATTTGACTACTGGGGCCAG
 S D T A M Y Y C A R F P N W G S F D Y W G Q
 CDR3
 GGAACCCCTGGTCACCGTCTCCTCA (SEQ ID NO:43)
 G T L V T V S S (SEQ ID NO:45)

FIG. 1

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GAAATTGTGTGACGAGTCTCCAGGCACCCCTGTCTTTGTCTCCAGGGGAAAGAGCCACCCCTCTCC
 E I V L T Q S P G T L S L S P G E R A T L S

 TGCAGGGCCAGTCAGAGTATTAGCAGCAGCTACTTAGCCCTGGTACCAGCAGAAACCTGGCCAGGCT
C R A S Q S I S S S Y L A W Y Q Q K P G Q A
 CDR1
 CCCAGGCTCCTCATCTATGGTGCATCCAGCAGGGCCACTGGCATCCACAGACAGGTTCAGTGGCAGT
 P R L L I Y G A S S R A T G I P D R F S G S
 CDR2
 GGGTCTGGGACAGACTTCACTCTCACCATCAGCAGACTGGAGCCTGAAGATTTTGCAGTGTATTAC
 G S G T D F T L T I S R L E P E D F A V Y Y

 TGTCAGCAGTATGAGACGTTTCGGCCCAAGGACCAAGGTGGAATCAAA (SEQ ID NO:47)
C Q Q Y E T F G G Q G T K V E I K (SEQ ID NO:49)
 CDR3

FIG. 2

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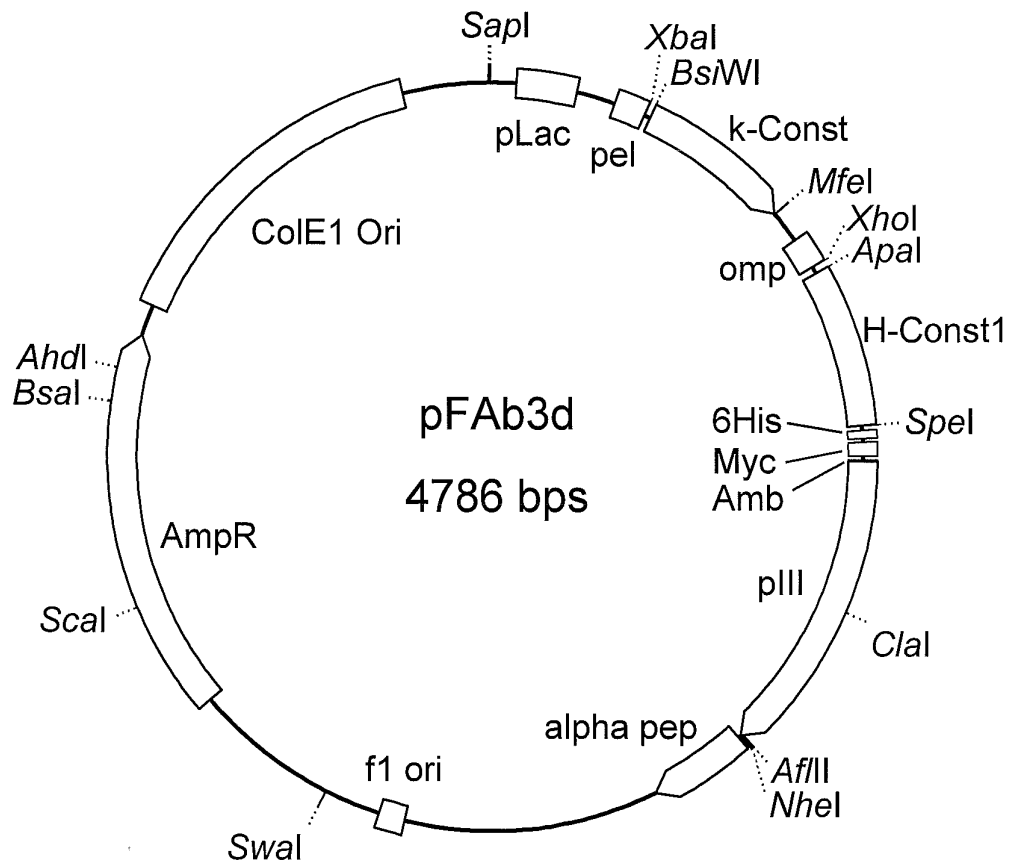


FIG. 3

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>pFab3d-10G5H
MKKTAIAIAVALAGFATVAQAALEEVQLVQSGAEVKKPGESLKISCKG
 ompA secretion signal
SGYSFTSYWIGWVRQMPGKGLEWMGVIYPGDSYTRYSPSFQGQVTISA
 CDR1 CDR2
DKSISTAYLQWSSLKASDTAMYYCARFPNWGSFDYWGQGTLVTVSSAS
 CDR3
TKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTSVWNSGALTSGV
 hCH1
HTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKRV
 hCH1
EPKSCDKTHTCPPCPTSGHHHHHHHGGEQKLISEEDLGG* PFVCEYQG
 His-tag Myc-tag ♦Amb
QSSDLPQPPVNAGGSGGGSGGGSEGGGGSEGGGGSEGGGGSEGGGGSGGGS
 pIII stump (aa198-406)
 GSGDFDYEKMANANKGAMTENADENALQSDAKGKLDSVATDYGAAIDGF
 IGDVSGLANGNGATGDFAGSNSQMAQVGDGDN SPLMNNFRQYLPSLPQS
 VECRPYVFGAGKPYEFSIDCDKINLFRGVFAFLLYVATFMYVFSTFANI
 LRNKES (SEQ ID NO:86)

FIG. 4A

>pFab3d-10G5L
MKYLLPTAAAGLLLLAAQPAMASREIVLTQSPGTLSLSPGERATLSCR
 Pel secretion signal
ASQSISSSYLAWYQQKPGQAPRLLIYGASSRATGIPDRFSGSGSGTDF
 CDR1 CDR2
TLTISRLEPEDFAVYYCQQYETFGQGTKVEIKRTVAAPSVFIFPPSDE
 CDR3
QLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDS
 Hck
TYSLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
 (SEQ ID NO: 87)

FIG. 4B

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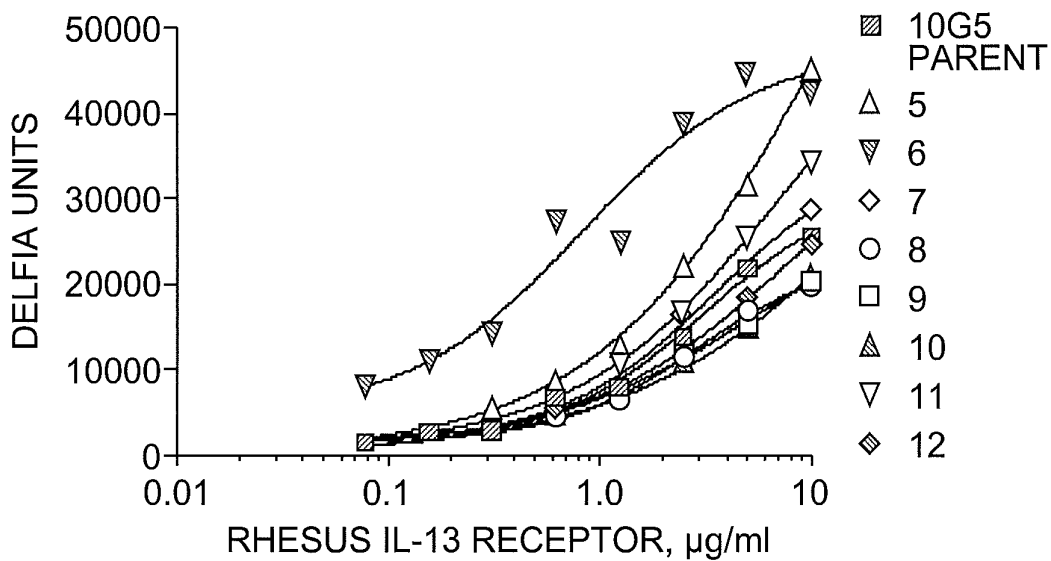


FIG. 5

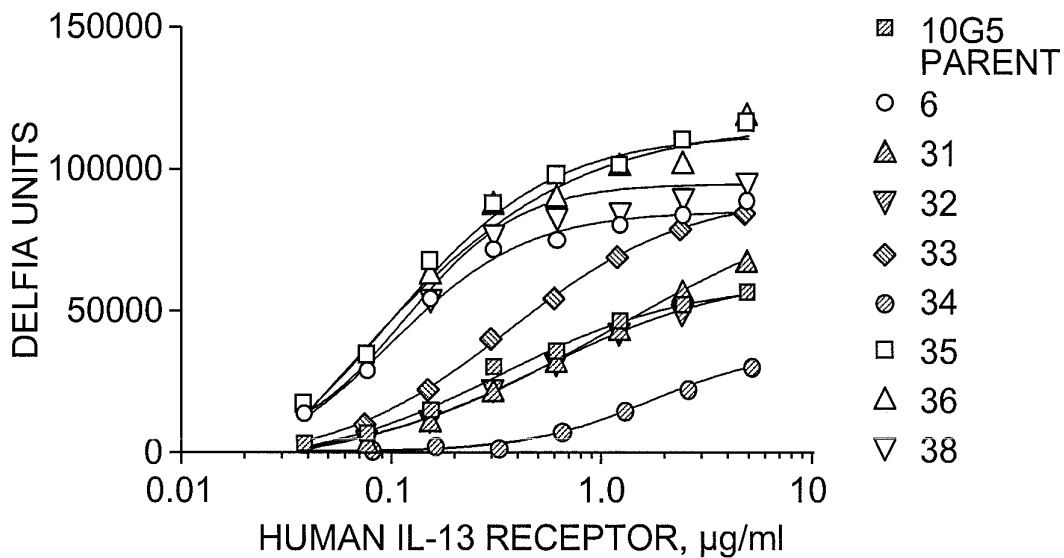


FIG. 6

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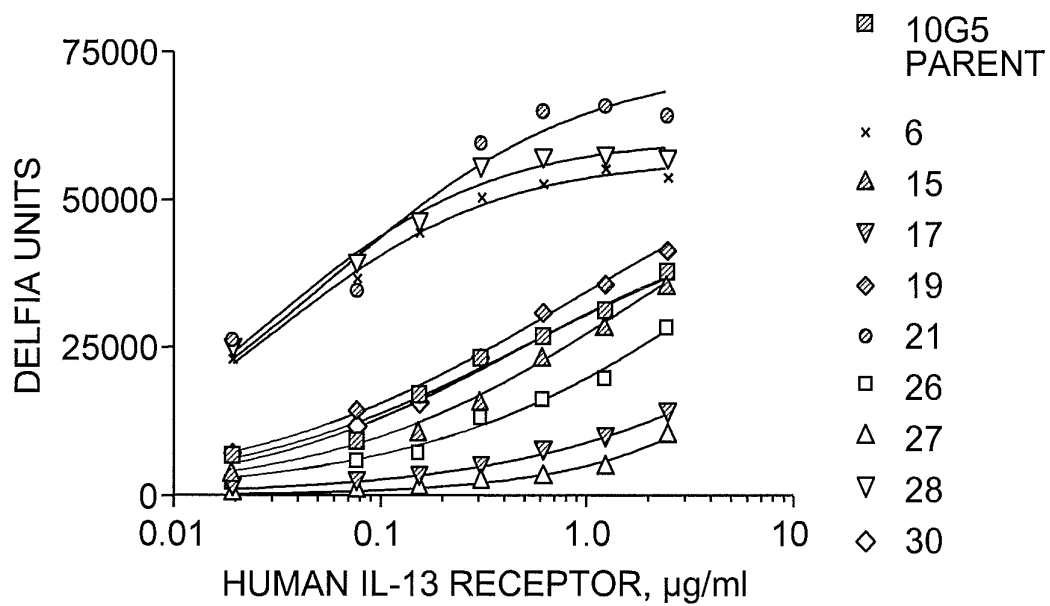


FIG. 7

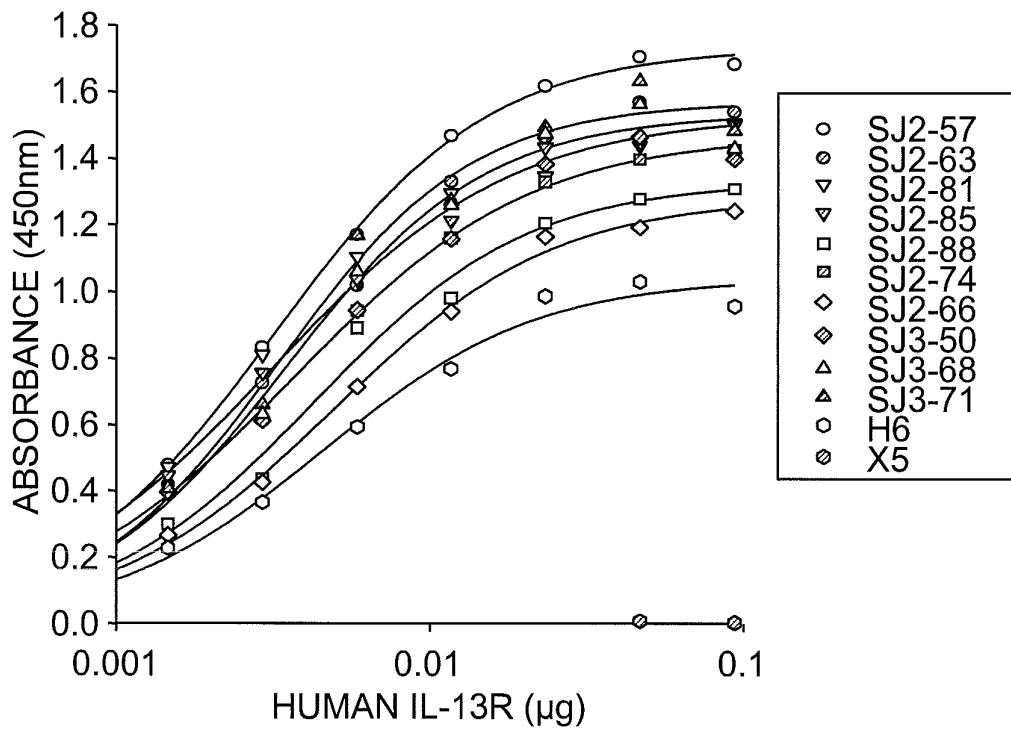
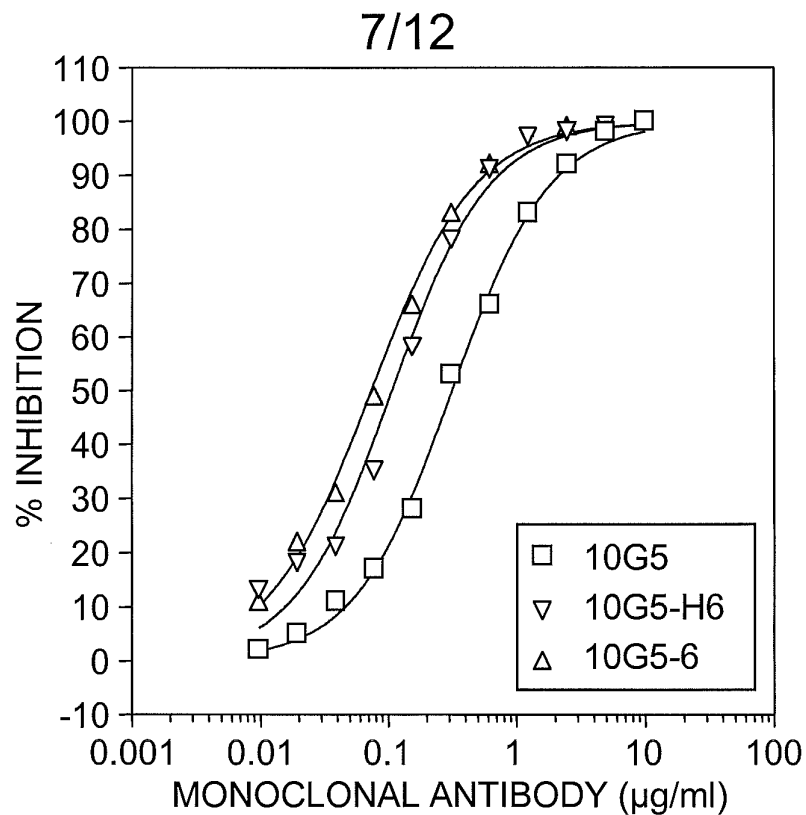
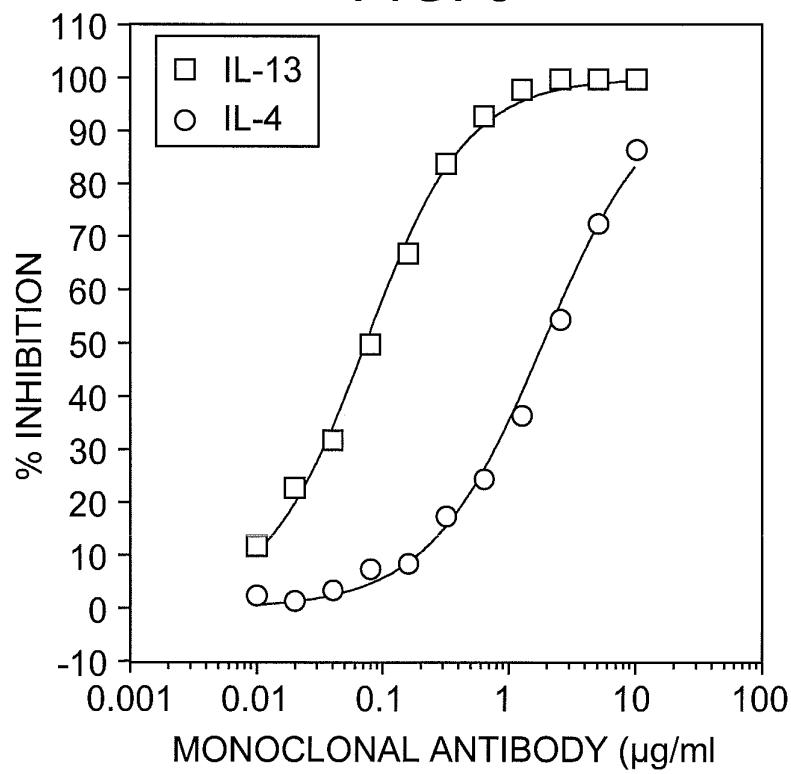
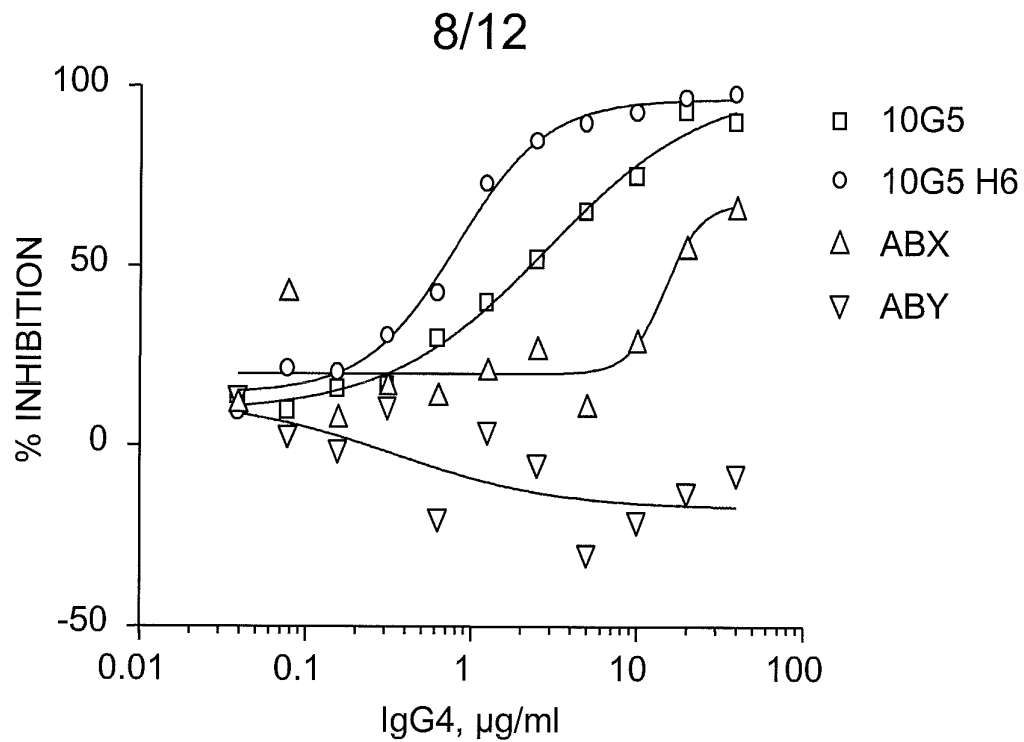
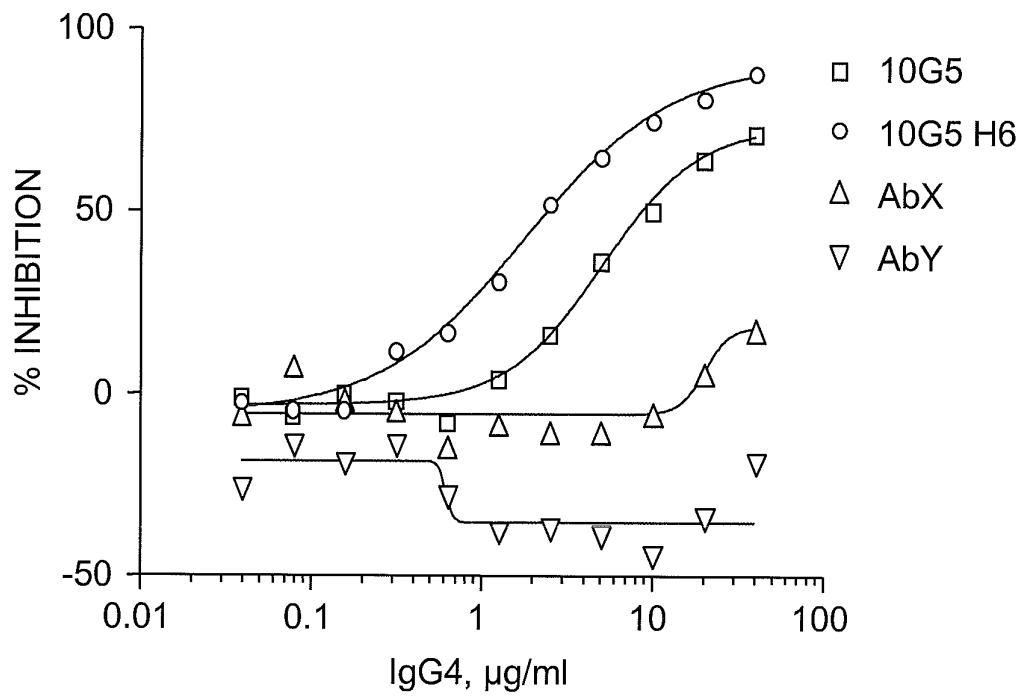
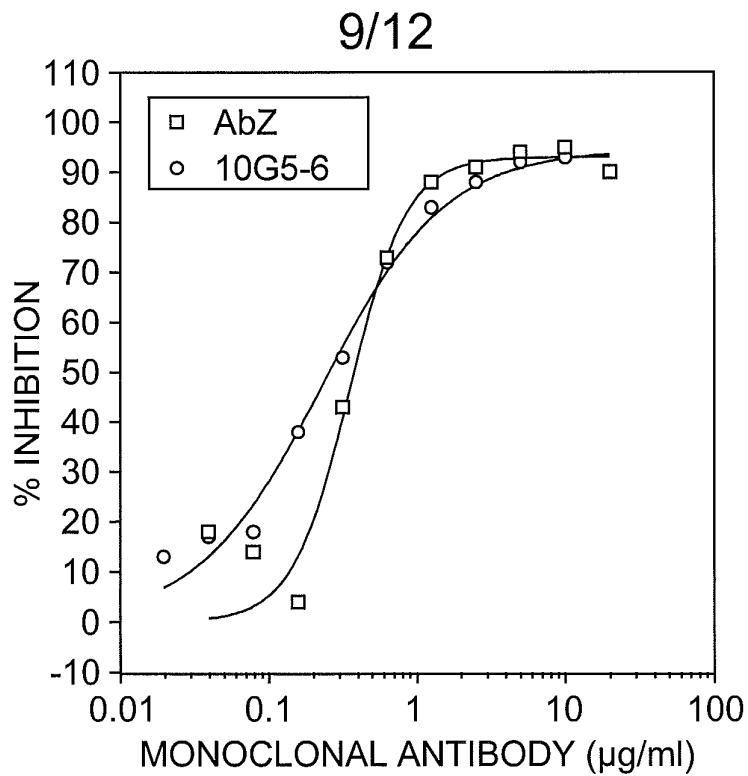
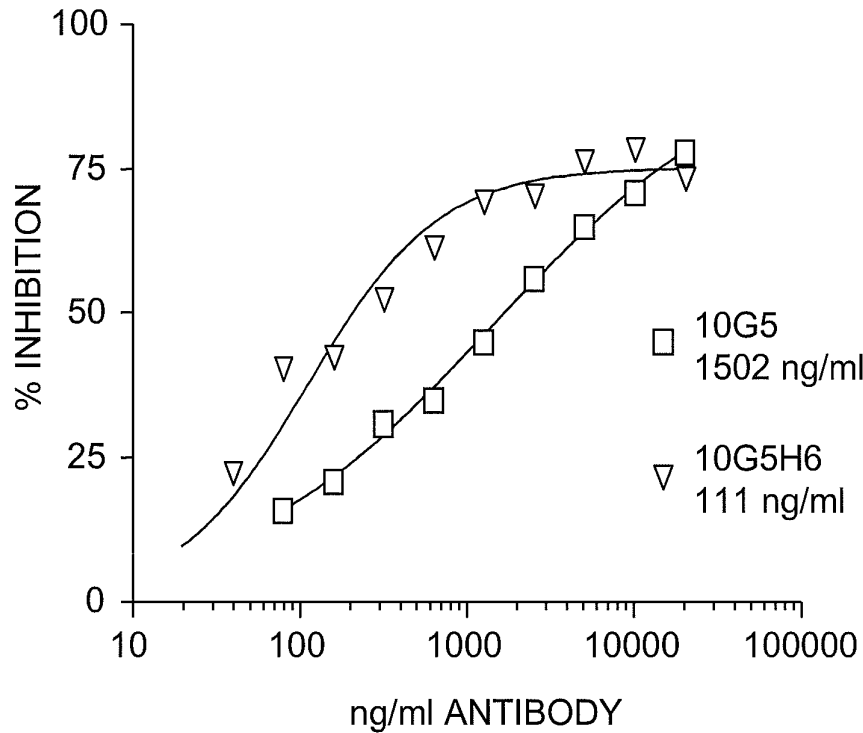


FIG. 8

**FIG. 9****FIG. 10**

*FIG. 11**FIG. 12*

**FIG. 13****FIG. 14**

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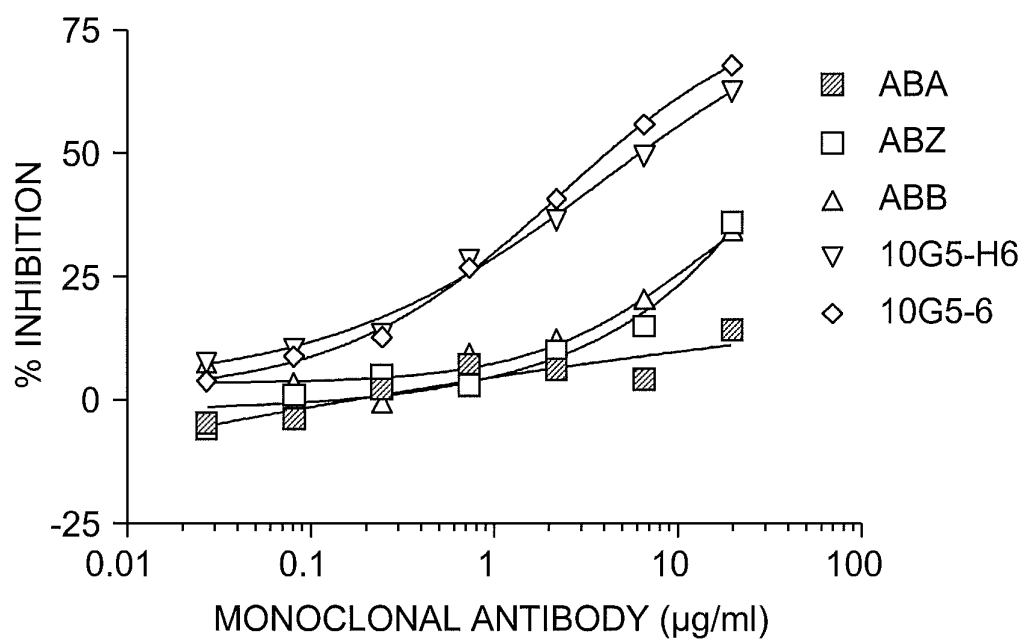


FIG. 15

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| --- CH1 STARTS HERE
IgG1  LVTVSSASTK GPSVFPLAPS SKSTSGGTAA LGCLVKDYFP EPVTVSWNSG
IgG2  LVTVSSASTK GPSVFPLAPC SRSTSESTAA LGCLVKDYFP EPVTVSWNSG
IgG4  LVTVSSASTK GPSVFPLAPC SRSTSESTAA LGCLVKDYFP EPVTVSWNSG
IgG2M4 LVTVSSASTK GPSVFPLAPC SRSTSESTAA LGCLVKDYFP EPVTVSWNSG
      (VH-C1 LINKER)

                                C200
IgG1  ALTSGVHTFP AVLQSSGLYS LSSVVTVPSS SLGTQTYICN VNHKPSNTKV
IgG2  ALTSGVHTFP AVLQSSGLYS LSSVVTVTSS NFGTQTYTCN VDHKPSNTKV
IgG4  ALTSGVHTFP AVLQSSGLYS LSSVVTVPSS SLGTQTYTCN VDHKPSNTKV
IgG2M4 ALTSGVHTFP AVLQSSGLYS LSSVVTVTSS NFGTQTYTCN VDHKPSNTKV

-HINGE REGION--| | ----CH2-> P238          M252          C261
IgG1  DKKAEPKSCD KTHTCPPCPA PELLGGPSVF LFPPKPKDTL MISRTPPEVTC
IgG2  DKTVERKCC- --VECPPCPA PP-VAGPSVF LFPPKPKDTL MISRTPPEVTC
IgG4  DKRVESKYGP ---PCPSCPA PEFLLGGPSVF LFPPKPKDTL MISRTPPEVTC
IgG2M4 DKTVERKCC- --VECPPCPA PP-VAGPSVF LFPPKPKDTL MISRTPPEVTC
      (LOWER HINGE)          FcRn-BIND

      D265 D270          N297*          T307
IgG1  VVVVDVSHEDP EVKFNWYVDG VEVHNAKTKP REEQYNSTYR VVSVLTIVLHQ
IgG2  VVVVDVSHEDP EVQFNWYVDG VEVHNAKTKP REEQFNSTFR VVSVLTIVVHQ
IgG4  VVVVDVSOEDP EVQFNWYVDG VEVHNAKTKP REEQFNSTYR VVSVLTIVLHQ
IgG2M4 VVVVDVSOEDP EVQFNWYVDG VEVHNAKTKP REEQFNSTFR VVSVLTIVLHQ
      B/C LOOP          C'E LOOP          FcRn-BIND

      C321          P329          | ----CH3->
IgG1  DWLNGKEYKC KVSNAKLPAPI EKTISKAKG QPREPQVYTL PPSRDELTKN
IgG2  DWLNGKEYKC KVSNAKGLPAPI EKTISKTKG QPREPQVYTL PPSREEMTKN
IgG4  DWLNGKEYKC KVSNAKGLPSSI EKTISKAKG QPREPQVYTL PPSQEEMTKN
IgG2M4 DWLNGKEYKC KVSNAKGLPSSI EKTISKTKG QPREPQVYTL PPSREEMTKN
      F/G LOOP

IgG1  QVSLTCLVKG FYPSDIAVEW ESNGQPENNY KTTTPVLDSD GSFFLYSKLT
IgG2  QVSLTCLVKG FYPSDIAVEW ESNGQPENNY KTTTPMLDSD GSFFLYSKLT
IgG4  QVSLTCLVKG FYPSDIAVEW ESNGQPENNY KTTTPVLDSD GSFFLYSRLT
IgG2M4 QVSLTCLVKG FYPSDIAVEW ESNGQPENNY KTTTPMLDSD GSFFLYSKLT

                                H433
IgG1  VDKSRWQQGN VFSCSVMHEA LHNHYTQKSL SLSPGK* (SEQ ID NO:97)
IgG2  VDKSRWQQGN VFSCSVMHEA LHNHYTQKSL SLSPGK* (SEQ ID NO:98)
IgG4  VDKSRWQQGN VFSCSVMHEA LHNHYTQKSL SLSLGK* (SEQ ID NO:99)
IgG2M4 VDKSRWQQGN VFSCSVMHEA LHNHYTQKSL SLSPGK* (SEQ ID NO:100)
      FcRn-BIND

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FIG. 16

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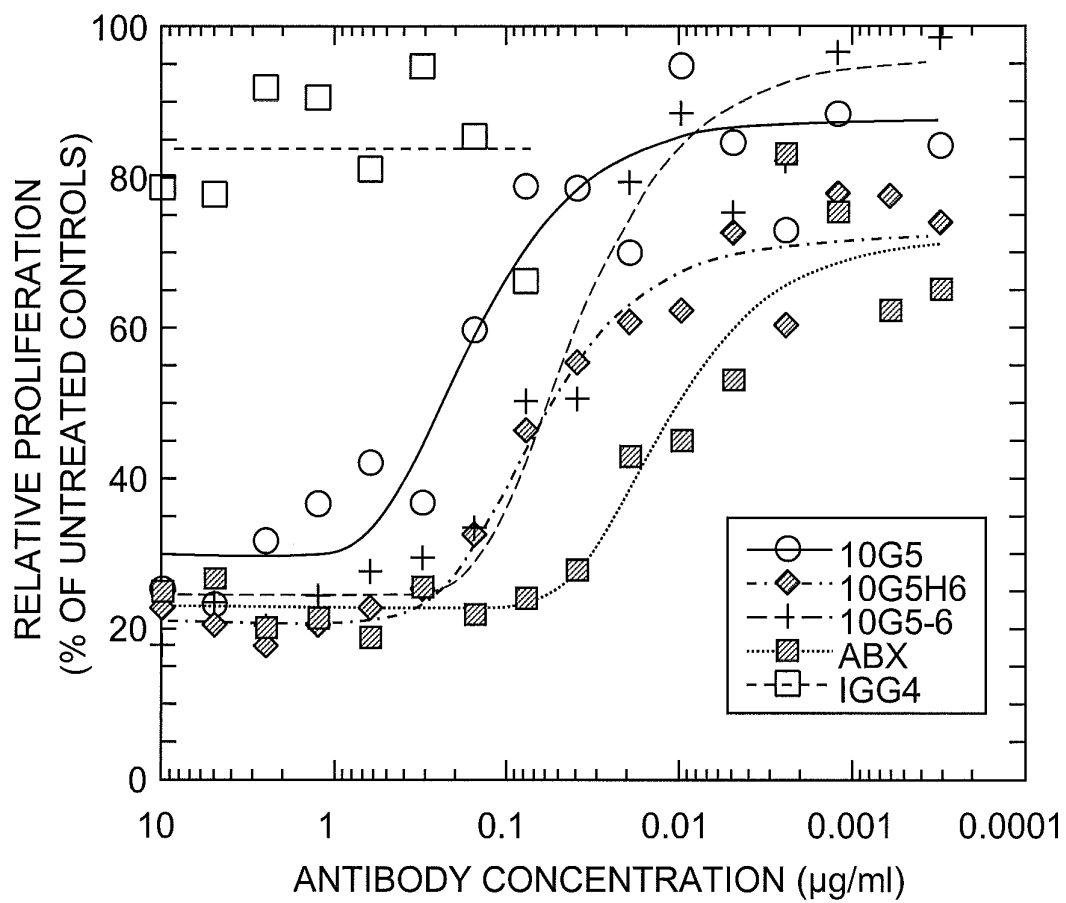


FIG. 17