ORGANIC MOLECULES

Field of use

The present invention relates to specific binding members, in particular human anti-IL-13 antibody molecules and especially those which neutralize IL-13 activity. It further relates to methods for using anti-IL-13 antibody molecules in diagnosis or treatment of IL-13 related disorders, such as asthma, atopic dermatitis, allergic rhinitis, fibrosis, inflammatory bowel disease and Hodgkin's lymphoma.

Background of the invention

Interleukin (IL) -13 is a 114 amino acid cytokine with an unmodified molecular mass of approximately 12 kDa [McKenzie, A. N. , et al. J Immunol, 1993.150 (12): p. 5436-44, and Minty, A. , et al. Nature, 1993.362 (6417): p. 248-50.]. IL-13 is most closely related to IL-4 with which it shares 30% sequence similarity at the amino acid level. The human IL-13 gene is located on chromosome 5q31 adjacent to the IL-4 gene. This region of chromosome 5q contains gene sequences for other Th2 lymphocyte derived cytokines including GM-CSF and IL-5, whose levels together with IL-4 have been shown to correlate with disease severity in asthmatics and rodent models of allergic inflammation [Nakamura, Y. , et al. Am J Respir Cell Mol Biol, 1996. 15 (5): p. 680-7, Robinson, D. S. , et al. N Engl J Med, 1992.326 (5): p. 298-304, Walker, C. , et al. Am J Respir Crit Care Med, 1994. 150 (4): p. 1038-48, Humbert, M. , et al. Am J Respir Crit Care Med, 1996,154 (5): p. 1497-504, Corrigan, C. J. and A. B. Kay Int Arch Allergy Appl Immunol, 1991. 94 (1-4): p.270-1, Bentley, A. M. , et al. Am J Respir Cell Mol Biol, 1993.].

Although initially identified as a Th2 CD4+ lymphocyte derived cytokine, IL-13 is also produced by Th1 CD4+ T-cells, CD8+ T lymphocytes NK cells, and non-T-cell populations such as mast cells, basophils, eosinophils, macrophages, monocytes and airway smooth muscle cells.

IL-13 is reported to mediate its effects through a receptor system that includes the IL-4 receptor a chain (IL-4Rα)-, which itself can bind IL-4 but not IL-13, and at least two other cell surface proteins, IL-13$R\alpha_1$ and IL-13$R\alpha_2$ [Murata, T. , et al. Int J Hematol, 1999. 69(1) : p.13-20, Andrews, A.L., et al. J Biol Chem, 2002.277(48) : p. 46073-8.]. IL-13$R\alpha_1$ can bind IL-13 with low affinity, subsequently recruiting IL- 4Rα to form a high affinity functional receptor that signals [Miloux, B. , et al. FEBS Lett, 1997.401 (2-3): p. 163-6, Hilton, D. J. , et

al. Proc Natl Acad Sci U S A, 1996. 93 (1): p. 497-501]. The Genbank database lists the amino acid sequence and the nucleic acid sequence of IL-13Rα_1 as NP 001551 and Y10659 respectively. Studies in STAT6 (signal transducer and activator of transcription 6) -deficient mice have revealed that IL-13, in a manner similar to IL-4, signals by utilizing the JAK-STAT6 pathway [Kuperman, D., et al. J Exp Med, 1998. 187 (6): p. 939-48, Nelms, K. , et al. Annu Rev Immunol, 1999.17 : p. 701-38.]. IL-13Rα_2 shares 37% sequence identity with IL-13Rα_1 at the amino acid level and binds IL-13 with high affinity [Zhang, J. G. , et al. J Biol Chem, 1997.272 (14): p. 9474- 80, Caput, D. , et al. J Biol Chem, 1996.271 (28): p. 16921-6.]. However, IL-13Rα_2 has a shorter cytoplasmic tail that lacks known signaling motifs. Cells expressing IL-13Rα_2 are not responsive to IL-13 even in the presence of IL-4Rα [Kawakami, K. , et al. Blood, 2001.97 (9): p. 2673-9]. It is postulated, therefore, that IL-13Rα_2 acts as a decoy receptor regulating IL-13 but not IL-4 function. This is supported by studies in IL-13Rα_2 deficient mice whose phenotype was consistent with increased responsiveness to IL-13 [Wood, N. , et al. J Exp Med, 2003.197 (6): p. 703-709, Chiaramonte, M. G. , et al. J Exp Med, 2003.197 (6): p. 687-701]. The Genbank database lists the amino acid sequence and the nucleic acid sequence of IL- 13Rα_2 as NP000631 and Y08768 respectively.

Summary of the invention

An embodiment of the invention herein provides an isolated human or humanized antibody or functional fragment thereof with an antigen-binding region that is specific for target protein IL-13 and the antibody or functional fragment thereof binds to IL-13. In a related embodiment, the binding to IL-13 is determined at least by cell surface IL-13 receptor binding preventing inflammatory mediator release.

In still another embodiment, the invention provides an isolated antigen-binding region of an antibody or functional fragment thereof. In certain embodiments, the isolated antigen-binding region includes an H-CDR3 region having an amino acid sequence selected from SEQ ID NOs: 9-10, and conservative variants thereof. As described herein, the conservative variants include amino acid residues in any of the amino acid sequences identified. In a related embodiment, the isolated antigen-binding region is an H-CDR2 region having the amino acid sequence of SEQ ID NO: 8, and conservative variants thereof. In another related embodiment, the isolated antigen-binding region is an H-CDR1 region having an amino acid sequence selected from SEQ ID NO: 6-7, and conservative variants thereof.

In another embodiment, the isolated antigen-binding region is an L-CDR3 region having an amino acid sequence selected from SEQ ID NOs: 20-22, and conservative variants thereof. In still another related embodiment, the isolated antigen-binding region is an L-CDR1 region having an amino acid sequence selected from SEQ ID NOs: 16-18, and conservative variants thereof. In yet another related embodiment, the isolated antigen-binding region is an L-CDR2 region having the amino acid sequence of SEQ ID NO: 19, and conservative variants thereof.

In certain embodiments, the isolated antigen-binding region is a variable light chain having an amino acid sequence selected from SEQ ID 16-22, and conservative variants thereof.

In another embodiment, the isolated antigen-binding region is a heavy chain having an amino acid sequence selected from one to three of SEQ ID 6-10, and a sequence having at least 60, 70, 80, 90 or 95 percent sequence identity in the CDR regions with the CDR regions having SEQ ID NOs: 6-10. In a related embodiment, the isolated antigen-binding region is a light chain having an amino acid sequence selected from one to three of SEQ ID NOs: 16-22, and a sequence having at least 60, 70, 80, 90 or 95 percent sequence identity in the CDR regions with the CDR regions having SEQ ID NOs: 16-22.

In a certain embodiment, the isolated antibody is an IgG. In another embodiment, the isolated antibody is an IgG1or an IgG4.

In yet another embodiment, the invention provides an isolated human or humanized antibody or functional fragment thereof, having an antigen-binding region that is specific for an epitope of IL-13, and the antibody or functional fragment binds to IL-13 surface receptors on a cell. In a related embodiment, the invention provides an isolated human or humanized antibody or functional fragment thereof, having an antigen-binding region that is specific for an epitope of target IL-13, and the epitope contains one or more amino acid residues of amino acid residues 1-112 of target IL-13. In a related embodiment, the epitope is a conformational epitope.

In yet another embodiment, the antibody or functional fragment is a Fab or scFv antibody fragment. In a related embodiment, the isolated antibody is an IgG. In another related embodiment, the isolated antibody is an IgG1 or an IgG4.

In another embodiment, the invention provides a pharmaceutical composition having at least one of any of the above antibodies or functional fragments or conservative variants, and a pharmaceutically acceptable carrier or excipient therefor.

In still another embodiment, the invention provides for a transgenic animal carrying a gene encoding any of the above antibodies or functional fragments thereof.

In certain embodiments, the invention provides a method for treating a disorder or condition associated with the presence of a cell having a receptor target for IL-13. The method involves administering to a subject in need thereof an effective amount of any of the above pharmaceutical compositions. In a related embodiment, the disorder or condition to be treated is a respiratory disorder.

In another embodiment, the disorder or condition to be treated is bronchial asthma, which is a common persistent inflammatory disease of the lung characterised by airways hyper-responsiveness (AHR), mucus overproduction, fibrosis and raised serum IgE levels. Li et al, Abstract for poster submitted at The American Thoraics Society Annual Meeting, 2003, Seattle, reported affects of a neutralising anti-mouse IL-13 antibody in a chronic mouse model of asthma.

In another embodiment, the disorder or condition to be treated is Chronic Obstructive Pulmonary Disease (COPD). Zheng et al J Clin Invest, 2000.106 (9): p. 1081-93, have demonstrated that over expression of IL- 13 in the mouse lung caused emphysema, elevated mucus production and inflammation, reflecting aspects of human COPD. mRNA levels of IL-13 have been shown to be higher in autopsy tissue samples from subjects with a history of COPD when compared to lung samples from subjects with no reported lung disease (J. Elias, Oral communication at American Thoracic Society Annual Meeting 2002). In another study, raised levels of IL-13 were demonstrated by immunohistochemistry in peripheral lung sections from COPD patients [Wardlaw, A. J. , Clin Med, 2001.1 (3): p. 214-8.].

In another embodiment, the disorder or condition to be treated is selected from other inflammatory or obstructive airways diseases and conditions such as acute lung injury (ALI), acute/adult respiratory distress syndrome (ARDS), dyspnea, allergic airway inflammation, small airway disease, lung carcinoma, acute chest syndrome in patients with sickle cell disease and pulmonary hypertension, as well as exacerbation of airways hyperreactivity consequent to other drug therapy, in particular other inhaled drug therapy.

In another embodiment, the disorder or condition to be treated is bronchitis of whatever type or genesis including, e.g., acute, arachidic, catarrhal, croupus, chronic or phthinoid bronchitis.

In another embodiment, the disorder or condition to be treated includes pneumoconiosis (an inflammatory, commonly occupational, disease of the lungs, frequently accompanied by airways obstruction, whether chronic or acute, and occasioned by repeated

inhalation of dusts) of whatever type or genesis, including, for example, aluminosis, anthracosis, asbestosis, chalicosis, ptilosis, siderosis, silicosis, tabacosis and byssinosis.

In another embodiment, the disorder or condition to be treated is selected from atopic rhinitis (hay fever), allergic dermatitis (eczema) and chronic sinusitis. Raised levels of IL-13 have been measured in human subjects with atopic rhinitis (hay fever), allergic dermatitis (eczema) and chronic sinusitis. For example levels of IL-13 were found to be higher in bronchial biopsies, sputum and broncho-alveolar lavage (BAL) cells from asthmatics compared to control subjects [Humbert, M. , et al. J Allergy Clin Immunol, 1997.99 (5): p. 657-65, Kotsimbos, T. C. , P. Ernst, and Q. A. Hamid, Proc Assoc Am Physicians, 1996.108 (5): p. 368-73, Komai-Koma, M. , F. Y.Liew, and P. C. Wilkinson, J Immunol, 1995.155 (3): p. 1110-6, Naseer, T. , et al. Am J Respir Crit Care Med, 1997].

In another embodiment, the disorder or condition to be treated is selected from other inflammatory conditions of the skin, for example, psoriasis or lupus erythematosus.

In another embodiment, the disorder or condition to be treated is inflammatory bowel disease, such as ulcerative colitis and Crohn's disease. Heller et al. (2002) Immunity, 17 (5): 629-38, report that neutralisation of IL-13 by administration of soluble IL-13Ra2 ameliorated colonic inflammation in a murine model of human ulcerative colitis. Correspondingly, IL-13 expression was higher in rectal biopsy specimens from ulcerative colitis patients when compared to controls.

In another embodiment, the disorder or condition to be treated is selected from other fibrotic conditions, such as systemic sclerosis, pulmonary fibrosis, idiopathic pulmonary fibrosis or fibroid lung. Increased levels of IL-13 have been measured in the serum of patients with systemic sclerosis [Hasegawa, M. , et al. J Rheumatol, 1997. 24 (2): p. 328-32] and in BAL samples from patients affected with other forms of pulmonary fibrosis [Hancock, A. , et al. Am J Respir Cell Mol Biol, 1998].

In another embodiment, the disorder or condition to be treated is liver fibrosis. Specific inhibition of IL-13 by administration of soluble IL-13Ra2 or IL-13 gene disruption, but not ablation of IL-4 production prevented fibrogenesis in the liver [Fallon, P. G. , et al. J Immunol, 2000.164 (5): p. 2585-91, Chiaramonte, M.G., et al. J Clin Invest, 1999.104 (6): p. 777-85, Chiaramonte, M. G. , et al. Hepatology, 2001.34(2) : p. 273-82.].

In another embodiment, the disorder or condition to be treated is Hodgkin's disease. Hodgkin's disease is unusual among malignancies in that the neoplastic Reed-Sternberg cell, often derived from B-cells, make up only a small proportion of the clinically detectable mass. Hodgkin's disease-derived cell lines and primary ReedSternberg cells frequently express IL-

13 and its receptor [Skinnider, B. F. , et al. Blood, 2001.97(1) : p. 250-5]. As IL-13 promotes cell survival and proliferation in normal B-cells, it was proposed that IL-13 could act as a growth factor for Reed-Sternberg cells. Skinnider et al. have demonstrated that neutralising antibodies against IL-13 can inhibit the growth of Hodgkin's disease-derived cell lines in vitro [Kapp, U. , et al. J Exp Med, 1999. 189 (12): p. 1939-46.]. This finding suggested that Reed-Sternberg cells might enhance their own survival by an IL-13 autocrine and paracrine cytokine loop. Consistent with this hypothesis, raised levels of IL-13 have been detected in the serum of some Hodgkin's disease patients when compared to normal controls [Fiumara, P. , F. Cabanillas, and A. Younes, Blood, 2001. 98 (9): p.2877-8.]. IL-13 inhibitors may therefore prevent disease progression by inhibiting proliferation of malignant Reed-Sternberg cells.

In another embodiment, the disorder or condition to be treated is tumour recurrence or metastasis. Inhibition of IL-13 has been shown to enhance anti-viral vaccines in animal models and may be beneficial in the treatment of HIV and other infectious diseases [Ahlers, J. D. , et al. Proc Natl Acad Sci U S A, 2002]. Many human cancer cells express immunogenic tumour specific antigens. However, although many tumours spontaneously regress, a number evade the immune system (immunosurveillance) by suppressing T-cell mediated immunity. Terabe et al. Nat Immunol, 2000.1 (6): p. 515-20, have demonstrated a role of IL-13 in immunosuppression in a mouse model in which tumours spontaneously regress after initial growth and then recur. Specific inhibition of IL-13, with soluble IL-13Ra2, protected these mice from tumour recurrence. Terabe et al went on to show that IL-13 suppresses the differentiation of tumour specific CD8+ cytotoxic lymphocytes that mediate anti-tumour immune responses.

In another embodiment, the disorder or condition to be treated is a respiratory viral infection, which exacerbates underlying chronic conditions such as asthma, chronic bronchitis, COPD, otitis media, and sinusitis. The respiratory viral infection treated may be associated with secondary bacterial infection, such as otitis media, sinusitis or pneumonia.

In another embodiment, the disorder or condition to be treated is selected from other diseases or conditions, in particular diseases or conditions having an inflammatory component, for example, diseases of the bone and joints including rheumatoid arthritis, psoriatic arthritis, and other diseases such as atherosclerosis, multiple sclerosis, and acute and chronic allograft rejection, e.g. following transplantation of heart, kidney, liver, lung or bone marrow.

In another embodiment, the disorder or condition to be treated is endotoxic shock, glomerulonephritis, cerebral and cardiac ischemia, Alzheimer's disease, cystic fibrosis, virus infections and the exacerbations associated with them, acquired immune deficiency syndrome (AIDS), multiple sclerosis (MS), *Helicobacter pylori* associated gastritis, and cancers, particularly the growth of ovarian cancer.

In another embodiment, the disorder or condition to be treated is the symptoms caused by viral infection in a human which is caused by the human rhinovirus, other enterovirus, coronavirus, herpes viruses, influenza virus, parainfluenza virus, respiratory syncytial virus or an adenovirus.

Treatment in accordance with the present invention may be symptomatic or prophylactic.

The effectiveness of an agent of the invention in inhibiting inflammatory conditions, for example in inflammatory airways diseases, may be demonstrated in an animal model, e.g. mouse, rat or rabbit model, of airway inflammation or other inflammatory conditions, for example as described by Wada et al, *J. Exp. Med* (1994) 180:1135-40; Sekido et al, *Nature* (1993) 365:654-57; Modelska et al., *Am. J. Respir. Crit. Care. Med* (1999) 160:1450-56; and Laffon et al (1999) *Am. J. Respir. Crit. Care Med.* 160:1443-49.

In yet another embodiment, the invention provides a method for identifying a cell having a receptor for IL-13. This method involves contacting the cell with any of the above antibodies or antibody fragments further having a detectable label. The label is radioactive, fluorescent, magnetic, paramagnetic, or chemiluminescent. The method further can involve any of the above imaging or separating the labeled cell.

In another embodiment, any of the above human or humanized antibodies or antibody fragments are synthetic.

In another embodiment, the invention provides a pharmaceutical composition and an additional therapeutic agent.

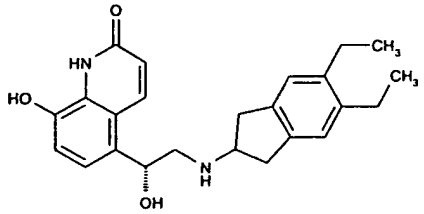
The additional therapeutic agent can be selected from the group consisting of anti-inflammatory, bronchodilatory, antihistamine or anti-tussive drug substances, particularly in the treatment of obstructive or inflammatory airways diseases such as those mentioned hereinbefore, for example as potentiators of therapeutic activity of such drugs or as a means of reducing required dosaging or potential side effects of such drugs. A therapeutic agent of the invention may be mixed with the other drug substance in a fixed pharmaceutical composition or it may be administered separately, before, simultaneously with or after the other drug substance. Accordingly the invention includes a combination of

an agent of the invention as hereinbefore described with an anti-inflammatory, bronchodilatory, antihistamine or anti-tussive drug substance, said agent of the invention and said drug substance being in the same or different pharmaceutical composition.

Suitable anti-inflammatory drugs include steroids, in particular glucocorticosteroids such as budesonide, beclamethasone dipropionate, fluticasone propionate, ciclesonide or mometasone furoate, or steroids described in WO 02/88167, WO 02/12266, WO 02/100879, WO 02/00679 (especially those of Examples 3, 11, 14, 17, 19, 26, 34, 37, 39, 51, 60, 67, 72, 73, 90, 99 and 101), WO 03/35668, WO 03/48181, WO 03/62259, WO 03/64445, WO 03/72592, WO 04/39827 and WO 04/66920; non-steroidal glucocorticoid receptor agonists, such as those described in DE 10261874, WO 00/00531, WO 02/10143, WO 03/82280, WO 03/82787, WO 03/86294, WO 03/104195, WO 03/101932, WO 04/05229, WO 04/18429, WO 04/19935 and WO 04/26248; LTB4 antagonists such as BIIL 284, CP-195543, DPC11870, LTB4 ethanolamide, LY 293111, LY 255283, CGS025019C, CP-195543, ONO-4057, SB 209247, SC-53228 and those described in US 5451700; LTD4 antagonists such include montelukast, pranlukast, zafirlukast, accolate, SR2640, Wy-48,252, ICI 198615, MK-571, LY-171883, Ro 24-5913 and L-648051; PDE4 inhibitors such cilomilast (Ariflo® GlaxoSmithKline), Roflumilast (Byk Gulden),V-11294A (Napp), BAY19-8004 (Bayer), SCH-351591 (Schering-Plough), Arofylline (Almirall Prodesfarma), PD189659 / PD168787 (Parke-Davis), AWD-12-281 (Asta Medica), CDC-801 (Celgene), SelCID(TM) CC-10004 (Celgene), VM554/UM565 (Vernalis), T-440 (Tanabe), KW-4490 (Kyowa Hakko Kogyo), and those disclosed in WO 92/19594, WO 93/19749, WO 93/19750, WO 93/19751, WO 98/18796, WO 99/16766, WO 01/13953, WO 03/104204, WO 03/104205, WO 03/39544, WO 04/000814, WO 04/000839, WO 04/005258, WO 04/018450, WO 04/018451, WO 04/018457, WO 04/018465, WO 04/018431, WO 04/018449, WO 04/018450, WO 04/018451, WO 04/018457, WO 04/018465, WO 04/019944, WO 04/019945, WO 04/045607 and WO 04/037805; A_{2A} agonists such as those described in EP 1052264, EP 1241176, EP 409595A2, WO 94/17090, WO 96/02543, WO 96/02553, WO 98/28319, WO 99/24449, WO 99/24450, WO 99/24451, WO 99/38877, WO 99/41267, WO 99/67263, WO 99/67264, WO 99/67265, WO 99/67266, WO 00/23457, WO 00/77018, WO 00/78774, WO 01/23399, WO 01/27130, WO 01/27131, WO 01/60835, WO 01/94368, WO 02/00676, WO 02/22630, WO 02/96462, and WO 03/086408; and A_{2B} antagonists such as those described in WO 02/42298.

Suitable bronchodilatory drugs include anticholinergic or antimuscarinic agents, in particular ipratropium bromide, oxitropium bromide, tiotropium salts and CHF 4226 (Chiesi),

and glycopyrrolate, but also those described in EP 424021, US 3714357, US 5171744, WO 01/04118, WO 02/00652, WO 02/51841, WO 02/53564, WO 03/00840, WO 03/33495, WO 03/53966, WO 03/87094, WO 04/018422 and WO 04/05285; and beta-2 adrenoceptor agonists such as albuterol (salbutamol), metaproterenol, terbutaline, salmeterol fenoterol, procaterol, and especially, formoterol, carmoterol and pharmaceutically acceptable salts thereof, and compounds (in free or salt or solvate form) of formula I of WO 00/75114, which document is incorporated herein by reference, preferably compounds of the Examples thereof, especially a compound of formula



i.e., (5-[(R)-2-(5,6-Diethyl-indan-2-ylamino)-1-hydroxy-ethyl]-8-hydroxy-1H-quinolin-2-one) and pharmaceutically acceptable salts thereof, as well as compounds (in free or salt or solvate form) of formula I of WO 04/16601, and also compounds of EP 1440966, JP 05025045, WO 93/18007, WO 99/64035, US 2002/0055651, WO 01/42193, WO 01/83462, WO 02/66422, WO 02/ 70490, WO 02/76933, WO 03/24439, WO 03/42160, WO 03/42164, WO 03/72539, WO 03/91204, WO 03/99764, WO 04/16578, WO 04/22547, WO 04/32921, WO 04/33412, WO 04/37768, WO 04/37773, WO 04/37807, WO 04/39762, WO 04/39766, WO 04/45618 WO 04/46083 , WO 04/80964, EP1460064, WO 04/087142, WO 04/089892, EP 01477167, US 2004/0242622, US 2004/0229904, WO 04/108675, WO 04/108676, WO 05/033121, WO 05/040103 and WO 05/044787.

Suitable dual anti-inflammatory and bronchodilatory drugs include dual beta-2 adrenoceptor agonist / muscarinic antagonists such as those disclosed in US 2004/0167167, WO 04/74246 and WO 04/74812.

Suitable antihistamine drug substances include cetirizine hydrochloride, acetaminophen, clemastine fumarate, promethazine, loratidine, desloratidine, diphenhydramine and fexofenadine hydrochloride, activastine, astemizole, azelastine, ebastine, epinastine, mizolastine and tefenadine as well as those disclosed in JP 2004107299, WO 03/099807 and WO 04/026841.

Combinations of therapeutic agents of the invention and anticholinergic or antimuscarinic agents, steroids, beta-2 agonists, PDE4 inhibitors, dopamine receptor agonists, LTD4 antagonists or LTB4 antagonists may also be used. Other useful combinations of

agents of the invention with anti-inflammatory drugs are those with other antagonists of chemokine receptors, e.g. CCR-1, CCR-3, CCR-4, CCR-5, CCR-6, CCR-7, CCR-8, CCR-9 and CCR10, CXCR1, CXCR2, CXCR3, CXCR4, CXCR5, particularly CCR-5 antagonists such as Schering-Plough antagonists SC-351125, SCH-55700 and SCH-D, Takeda antagonists such as N-[[4-[[[6,7-dihydro-2-(4-methylphenyl)-5H-benzocyclohepten-8-yl]carbonyl]amino]phenyl]-methyl]-tetrahydro-N,N-dimethyl-2H-pyran-4-aminium chloride (TAK-770), CCR-5 antagonists described in US 6166037 (particularly claims 18 and 19), WO 0066558 (particularly claim 8), WO 0066559 (particularly claim 9), WO 04/018425 and WO 04/026873.

The additional therapeutic agent may also be selected from the group consisting of other cytokine binding molecules, particularly antibodies of other cytokines, in particular a combination with an anti-IL4 antibody, such as described in PCT/EP2005/00836, an anti-IgE antibody, such as Xolair®, an anti-IL31 antibody, an anti-IL31R antibody, an anti-TSLP antibody, an anti-TSLP receptor antibody, an anti-endoglin antibody, an anti-IL1b antibody or another anti-IL13 antibody, such as described in WO05/007699.

In a certain embodiment, the invention provides an antibody having a first amino acid sequence which is a heavy chain selected from one to three of SEQ ID NOs: 6-10, and a sequence having at least 60, 70, 80, 90 or 95 percent sequence identity in the CDR regions with the CDR regions having SEQ ID NOs: 6-10; and a second amino acid sequence which is a light chain selected from one to three of SEQ ID NOs: 16-22, and a sequence having at least 60, 70, 80, 90 or 95 percent sequence identity in the CDR regions with the CDR regions shown in SEQ ID NOs: 16-22.

In still another embodiment, the invention provides an immunoconjugate made out of a first component which is an antibody or fragment thereof and a second component having a second amino acid sequence. For example, the immunoconjugate is a cytotoxin, or the immunoconjugate is a binding protein or antibody having a binding specificity for a target that is different from IL-13.

In certain embodiments, the invention provides for a bispecific antibody.

In another embodiment, the invention provides a kit having an antibody or antibody fragment thereof. In some embodiments, the kit further contains a pharmaceutically acceptable carrier or excipient therefore. In other related embodiments, the antibody in the kit is present in a unit dose. In yet another related embodiment, the kit includes instructions for use in administering to a subject.

Detailed description of the invention

The present invention relates to isolated antibodies, particularly human antibodies, that bind specifically to IL-13 and that inhibit functional properties of IL-13. In certain embodiments, the antibodies of the invention are derived from particular heavy and light chain sequences and/or comprise particular structural features such as CDR regions comprising particular amino acid sequences. The invention provides isolated antibodies, methods of making such antibodies, immunoconjugates and bispecific molecules comprising such antibodies and pharmaceutical compositions containing the antibodies, immunconjugates or bispecific molecules of the invention. The invention also relates to methods of using the antibodies to inhibit a disorder or condition associated with the presence of cell receptor target IL-13, for example, in the treatment of an inflammatory or allergic condition, particularly an inflammatory or obstructive airways disease.

In order that the present invention may be more readily understood, certain terms are first defined. Additional definitions are set forth throughout the detailed description.

The term 'interleukin-13' or 'IL-13' is, except where context dictates otherwise, reference to human IL-13. The present invention provides antibodies to human IL-13, especially human antibodies, that are cross-reactive with non-human primate IL-13, including cynomolgus and rhesus monkey IL-13. Antibodies in accordance with some embodiments of the present invention recognise a variant of IL-13 in which the arginine residue at amino acid position 130 is replaced by glutamine. In other aspects and embodiments the present invention provides specific binding members against murine IL-13, specifically mouse IL-13.

The term "immune response" refers to the action of, for example, lymphocytes, antigen presenting cells, phagocytic cells, granulocytes, and soluble macromolecules produced by the above cells or the liver (including antibodies, cytokines, and complement) that results in selective damage to, destruction of, or elimination from the human body of invading pathogens, cells or tissues infected with pathogens, cancerous cells, or, in cases of autoimmunity or pathological inflammation, normal human cells or tissues.

A "signal transduction pathway" refers to the biochemical relationship between a variety of signal transduction molecules that play a role in the transmission of a signal from one portion of a cell to another portion of a cell. As used herein, the phrase "cell surface receptor" includes, for example, molecules and complexes of molecules capable of receiving a signal and capable of the transmission of such a signal across the plasma

membrane of a cell. An example of a "cell surface receptor" of the present invention is the IL-13 receptor to which the IL-13 protein molecule binds.

The term "antibody" as referred to herein includes whole antibodies and any antigen binding fragment (i. e., "antigen-binding portion") or single chains thereof. A naturally occurring "antibody" is a glycoprotein comprising at least two heavy (H) chains and two light (L) chains inter-connected by disulfide bonds. Each heavy chain is comprised of a heavy chain variable region (abbreviated herein as V_H) and a heavy chain constant region. The heavy chain constant region is comprised of three domains, CH1, CH2 and CH3. Each light chain is comprised of a light chain variable region (abbreviated herein as V_L) and a light chain constant region. The light chain constant region is comprised of one domain, C_L. The V_H and V_L regions can be further subdivided into regions of hypervariability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is, composed of three CDRs and four FRs arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. The constant regions of the antibodies may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (e.g., effector cells) and the first component (Clq) of the classical complement system.

The term "antigen-binding portion" of an antibody (or simply "antigen portion"), as used herein, refers to one or more fragments of an antibody that retain the ability to specifically bind to an antigen (e.g., IL-13). It has been shown that the antigen-binding function of an antibody can be performed by fragments of a full-length antibody. Examples of binding fragments encompassed within the term "antigen-binding portion" of an antibody include a Fab fragment, a monovalent fragment consisting of the V_L, V_H, C_L and CH1 domains; a $F(ab)_2$ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; a Fd fragment consisting of the V_H and CH1 domains; a Fv fragment consisting of the V_L and V_H domains of a single arm of an antibody; a dAb fragment (Ward et al., 1989 Nature 341:544-546), which consists of a V_H domain; and an isolated complementarity determining region (CDR).

Furthermore, although the two domains of the Fv fragment, V_L and V_H, are coded for by separate genes, they can 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 (known as single chain Fv (scFv); see e.g., Bird et al., 1988

Science 242:423-426; and Huston et al., 1988 Proc. Natl. Acad. Sci. 85:5879-5883). Such single chain antibodies are also intended to be encompassed within the term "antigen-binding portion" of an antibody. These antibody fragments are obtained using conventional techniques known to those of skill in the art, and the fragments are screened for utility in the same manner as are intact antibodies.

An "isolated antibody", as used herein, refers to an antibody that is substantially free of other antibodies having different antigenic specificities (e.g., an isolated antibody that specifically binds IL-13 is substantially free of antibodies that specifically bind antigens other than IL-13). An isolated antibody that specifically binds IL-13 may, however, have cross-reactivity to other antigens, such as IL-13 molecules from other species. Moreover, an isolated antibody may be substantially free of other cellular material and/or chemicals.

The terms "monoclonal antibody" or "monoclonal antibody composition" as used herein refer to a preparation of antibody molecules of single molecular composition. A monoclonal antibody composition displays a single binding specificity and affinity for a particular epitope.

The term "human antibody", as used herein, is intended to include antibodies having variable regions in which both the framework and CDR regions are derived from sequences of human origin. Furthermore, if the antibody contains a constant region, the constant region also is derived from such human sequences, e.g., human germline sequences, or mutated versions of human germline sequences. The human antibodies of the invention may include amino acid residues not encoded by human sequences (e.g., mutations introduced by random or site-specific mutagenesis in vitro or by somatic mutation in vivo). However, the term "human antibody", as used herein, is not intended to include antibodies in which CDR sequences derived from the germline of another mammalian species, such as a mouse, have been grafted onto human framework sequences.

The term "human monoclonal antibody" refers to antibodies displaying a single binding specificity which have variable regions in which both the framework and CDR regions are derived from human sequences. In one embodiment, the human monoclonal antibodies are produced by a hybridoma which includes a B cell obtained from a transgenic nonhuman animal, e.g., a transgenic mouse, having a genome comprising a human heavy chain transgene and a light chain transgene fused to an immortalized cell.

The term "recombinant human antibody", as used herein, includes all human antibodies that are prepared, expressed, created or isolated by recombinant means, such as antibodies isolated from an animal (e.g., a mouse) that is transgenic or transchromosomal for

human immunoglobulin genes or a hybridoma prepared therefrom, antibodies isolated from a host cell transformed to express the human antibody, e.g., from a transfectoma, antibodies isolated from a recombinant, combinatorial human antibody library, and antibodies prepared, expressed, created or isolated by any other means that involve splicing of all or a portion of a human immunoglobulin gene, sequences to other DNA sequences. Such recombinant human antibodies have variable regions in which the framework and CDR regions are derived from human germline immunoglobulin sequences. In certain embodiments, however, such recombinant human antibodies can be subjected to in vitro mutagenesis (or, when an animal transgenic for human Ig sequences is used, in vivo somatic mutagenesis) and thus the amino acid sequences of the V_H and V_L regions of the recombinant antibodies are sequences that, while derived from and related to human germline V_H and V_L sequences, may not naturally exist within the human antibody germline repertoire in vivo.

As used herein, "isotype" refers to the antibody class (e.g., IgM, IgE, IgG such as IgG1 or IgG4) that is encoded by the heavy chain constant region genes.

The phrases "an antibody recognizing an antigen" and " an antibody specific for an antigen" are used interchangeably herein with the term "an antibody which binds specifically to an antigen."

As used herein, an antibody that "specifically binds to human IL-13" is intended to refer to an antibody that binds to human IL-13 with a K_D of 5×10^{-9} M or less. An antibody that "cross-reacts with an antigen other than human IL-13" is intended to refer to an antibody that binds that antigen with a 5×10^{-9} M or less. An antibody that "does not cross-react with a particular antigen" is intended to refer to an antibody that binds to that antigen, with a K_D of 1.5×10^{-8} M or greater, or a K_D of $5\text{-}10 \times 10^{-8}$ M or 1×10^{-7} M or greater. In certain embodiments, such antibodies that do not cross-react with the antigen exhibit essentially undetectable binding against these proteins in standard binding assays.

As used herein, an antibody that "inhibits binding of IL-13 to the IL-13 receptor" refers to an antibody that inhibits IL-13 binding to the receptor with a KD of 5 nM or less.

As used herein, an antibody that "inhibits inflammatory mediator release" is intended to refer to an antibody that inhibits IL-13 induced eotaxin release from human lung fibroblasts with an IC_{50} less than 10 nM, 5 nM, 2.5 nM, 1.0 nM, 0.5 nM, or less.

The term "K_{assoc}" or "K_a", as used herein, is intended to refer to the association rate of a particular antibody-antigen interaction, whereas the term "K_{dis}" or "K_D," as used herein, is intended to refer to the dissociation rate of a particular antibody-antigen interaction. The term "K_D", as used herein, is intended to refer to the dissociation constant,

which is obtained from the ratio of K_d to K_a (i.e. K_d/K_a) and is expressed as a molar concentration (M). K_D values for antibodies can be determined using methods well established in the art. A method for determining the K_D of an antibody is by using surface plasmon resonance, or using a biosensor system such as a Biacore® system.

As used herein, the term "high affinity" for an IgG antibody refers to an antibody having a K_D of 10^{-8} M or less, 10^{-9} M or less, or 10^{-10} M or less for a target antigen.

As used herein, the term "subject" includes any human or nonhuman animal. The term "nonhuman animal" includes all vertebrates, e.g., mammals and non-mammals, such as nonhuman primates, sheep, dogs, cats, horses, cows chickens, amphibians, reptiles, etc.

Various aspects of the invention are described in further detail in the following subsections.

Standard assays to evaluate the binding ability of the antibodies toward IL-13 of various species are known in the art, including for example, ELISAs, western blots and RIAs. Suitable assays are described in detail in the Examples. The binding kinetics (e.g., binding affinity) of the antibodies also can be assessed by standard assays known in the art, such as by Biacore analysis. Assays to evaluate the effects of the antibodies on functional properties of IL-13 are described in further detail in the Examples.

Accordingly, an antibody that "inhibits" one or more of these IL-13 functional properties (e.g., biochemical, immunochemical, cellular, physiological or other biological activities, or the like) as determined according to methodologies known to the art and described herein, will be understood to relate to a statistically significant decrease in the particular activity relative to that seen in the absence of the antibody (e.g., or when a control antibody of irrelevant specificity is present). An antibody that inhibits IL-13 activity effects such a statistically significant decrease by at least 10% of the measured parameter, by at least 50%, 80% or 90%, and in certain embodiments an antibody of the invention may inhibit greater than 95%, 98% or 99% of IL-13 functional activity.

Monoclonal antibodies

Antibodies of the invention are the human monoclonal antibodies, isolated and structurally characterized as described, in Examples 1-5. The V_H amino acid sequences of the antibodies are shown in SEQ ID NOs: 6-10 respectively. The V_L amino acid sequences of the antibodies are shown in SEQ ID NOs: 16-22 respectively. Other antibodies of the invention include amino acids that have been mutated, yet have at least 60, 70, 80, 90 or 95

percent identity in the CDR regions with the CDR regions depicted in the sequences described above.

Since each of these antibodies can bind to IL-13, the V_H and V_L sequences can be "mixed and matched" to create other anti-IL-13 binding molecules of the invention. IL-13 binding of such "mixed and matched" antibodies can be tested using the binding assays described above and in the Examples (e.g., ELISAs). When V_H and V_L chains are mixed and matched, a V_H sequence from a particular V_H/V_L pairing should be replaced with a structurally similar V_H sequence. Likewise, a V_L sequence from a particular V_H/V_L pairing should be replaced with a structurally similar V_L sequence. The V_H and V_L sequences of the antibodies of the present invention are particularly amenable for mixing and matching, since these antibodies use V_H and V_L sequences derived from the same germline sequences and thus exhibit structural similarity.

In another aspect, the invention provides antibodies that comprise the heavy chain and light chain CDRls, CDR2s and CDR3s of the antibodies, or combinations thereof. The amino acid sequences of the V_H CDR1s of the antibodies are shown in SEQ ID NOs: 6-7. The amino acid sequence of the V_H CDR2s of the antibodies is shown by SEQ ID NO: 8. The amino acid sequences of the V_H CDR3s of the antibodies are shown in SEQ ID NOs: 9-10. The amino acid sequences of the V_L CDR1s of the antibodies are shown in SEQ ID NOs: 16-18. The amino acid sequences of the V_L CDR2s of the antibodies is shown in SEQ ID NO: 19. The amino acid sequences of the V_L CDR3s of the antibodies are shown in SEQ ID NOs: 20-22. The CDR regions are delineated using the Kabat system (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).

Given that each of these antibodies can bind to IL-13 and that antigen-binding specificity is provided primarily by the CDR1, 2 and 3 regions, the V_H CDR1, 2 and 3 sequences and V_L CDR1, 2 and 3 sequences can be "mixed and matched" (i.e., CDRs from different antibodies can be mixed and match, although each antibody must contain a V_H CDR1, 2 and 3 and a V_L CDR1, 2 and 3) to create other anti-IL-13 binding molecules of the invention. IL-13 binding of such "mixed and matched" antibodies can be tested using the binding assays described above and in the Examples (e.g., ELISAs). When V_H CDR sequences are mixed and matched, the CDR1, CDR2 and/or CDR3 sequence from a particular V_H sequence should be replaced with a structurally similar CDR sequence(s). Likewise, when V_L CDR sequences are mixed and matched, the CDR1, CDR2 and/or CDR3 sequence from a particular V_L sequence should be replaced with a structurally similar CDR

sequence(s). It will be readily apparent to the ordinarily skilled artisan that novel V_H and V_L sequences can be created by substituting one or more V_H and/or V_L CDR region sequences with structurally similar sequences from the CDR sequences shown herein for monoclonal antibodies of the present invention.

An isolated monoclonal antibody, or antigen binding portion thereof has: a heavy chain variable region CDR1 comprising an amino acid sequence selected from the group consisting of SEQ ID NOs: 6-7; a heavy chain variable region CDR2 comprising an amino acid sequence of SEQ ID NO: 8; a heavy chain variable region CDR3 comprising an amino acid sequence selected from the group consisting of SEQ ID NOs: 9-10; a light chain variable region CDR1 comprising an amino acid sequence selected from the group consisting of SEQ ID NOs: 16-18; a light chain variable region CDR2 comprising an amino acid sequence of SEQ ID NO: 19; and a light chain variable region CDR3 comprising an amino acid sequence selected from the group consisting of SEQ ID NOs: 20-22; wherein the antibody specifically binds IL-13.

In a certain embodiment, the antibody consists of: a heavy chain variable region CDR1 comprising SEQ ID NO: 6; a heavy chain variable region CDR2 comprising SEQ ID NO: 8; a heavy chain variable region CDR3 comprising SEQ ID NO: 9; a light chain variable region CDR1 comprising SEQ ID NO: 16; a light chain variable region CDR2 comprising SEQ ID NO: 19; and a light chain variable region CDR3 comprising SEQ ID NO: 20.

In another embodiment, the antibody consists of: a heavy chain variable region CDR1 comprising SEQ ID NO: 7; a heavy chain variable region CDR2 comprising SEQ ID NO: 8; a heavy chain variable region CDR3 comprising SEQ ID NO: 10; a light chain variable region CDR1 comprising SEQ ID NO: 17; a light chain variable region CDR2 comprising SEQ ID NO: 19; and a light chain variable region CDR3 comprising SEQ ID NO: 21.

In yet another embodiment, the antibody consists of: a heavy chain variable region CDR1 comprising SEQ ID NO: 7; a heavy chain variable region CDR2 comprising SEQ ID NO: 8; a heavy chain variable region CDR3 comprising SEQ ID NO: 10; a light chain variable region CDR1 comprising SEQ ID NO: 18; a light chain variable region CDR2 comprising SEQ ID NO: 19; and a light chain variable region CDR3 comprising SEQ ID NO: 22.

As used herein, a human antibody comprises heavy or light chain variable regions that is "the product of" or "derived from" a particular germline sequence if the variable regions of the antibody are obtained from a system that uses human germline immunoglobulin genes. Such systems include immunizing a transgenic mouse carrying human immunoglobulin genes with the antigen of interest or screening a human immunoglobulin gene library displayed on phage with the antigen of interest. A human antibody that is "the product of" or "derived from" a human germline immunoglobulin sequence can be identified as such by comparing the amino acid sequence of the human antibody to the amino acid sequences of human germline immunoglobulins and selecting the human germline immunoglobulin sequence that is closest in sequence (i.e., greatest % identity) to the sequence of the human antibody. A human antibody that is "the product of" or "derived from" a particular human germline immunoglobulin sequence may contain amino acid differences as compared to the germline sequence, due to, for example, naturally occurring somatic mutations or intentional introduction of site-directed mutation. However, a selected human antibody typically is at least 90% identical in amino acids sequence to an amino acid sequence encoded by a human germline immunoglobulin gene and contains amino acid residues that identify the human antibody as being human when compared to the germline immunoglobulin amino acid sequences of other species (e.g., murine germline sequences). In certain cases, a human antibody may be at least 60%, 70%, 80%, 90%, or at least 95%, or even at least 96%, 97%, 98%, or 99% identical in amino acid sequence to the amino acid sequence encoded by the germline immunoglobulin gene. Typically, a human antibody derived from a particular human germline sequence will display no more than 10 amino acid differences from the amino acid sequence encoded by the human germline immunoglobulin gene. In certain cases, the human antibody may display no more than 5, or even no more than 4, 3, 2, or 1 amino acid difference from the amino acid sequence encoded by the gennline immunoglobulin gene.

Homologous antibodies

In yet another embodiment, an antibody of the invention has heavy and light chain variable regions having amino acid sequences that are homologous to the amino acid sequences of the antibodies described herein, and wherein the antibodies retain the desired functional properties of the anti-IL-13 antibodies of the Invention.

For example, the invention provides an isolated monoclonal antibody, or antigen binding portion thereof, comprising a heavy chain variable region and a light chain variable region, wherein: the heavy chain variable region comprises an amino acid sequence that is at least 80% homologous to an amino acid sequence selected from the group consisting of SEQ ID NOs: 6-10; the light chain variable region comprises an amino acid sequence that is at least 80% homologous to an amino acid sequence selected from the group consisting of SEQ ID NOs: 16-22; the antibody specifically binds to IL-13, and the antibody exhibits at least one of the following functional properties: the antibody inhibits binding IL-13 protein to the IL-13 receptor or the antibody inhibits IL-13 receptor binding preventing or ameliorating an inflammatory or allergic condition, particularly an inflammatory or obstructive airways disease, or the antibody inhibits IL-13 receptor binding preventing or ameliorating asthma or the antibody inhibits IL-13 receptor binding preventing or ameliorating COPD.

In various embodiments, the antibody may exhibit one or more, two or more, or three of the functional properties discussed above. The antibody can be, for example, a human antibody, a humanized antibody or a chimeric antibody.

In other embodiments, the V_H and/or V_L amino acid sequences may be 60%, 70%, 80%, 90%, 95%, 96%, 97%, 98% or 99% homologous to the sequences set forth above. An antibody having V_H and V_L regions having high (i. e., 80% or greater) homology to the V_H and V_L regions of SEQ ID NOs: 6-10 and 16-22 respectively, can be obtained by mutagenesis (e.g., site-directed or PCR-mediated mutagenesis) of nucleic acid molecules encoding SEQ ID NOs: 6-10 and/or 16-22, followed by testing of the encoded altered antibody for retained function (i. e., the functions set forth above) 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 the 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 two sequences can be accomplished using a mathematical algorithm, as described in the non-limiting examples below.

The percent identity between two amino acid sequences can be determined using the algorithm of E. Meyers and W. Miller (Comput. Appl. Biosci., 4:11-17, 1988) which has been incorporated into the ALIGN program (version 2.0), using a PAM120 weight residue table, a gap length penalty of 12 and a gap penalty of 4. In addition, the percent identity

between two amino acid sequences can be determined using the Needleman and Wunsch (J. Mol, Biol. 48:444-453, 1970) algorithm which has been incorporated into the GAP program in the GCG software package (available at http://www.gcg.com), using either a Blossom 62 matrix or a PAM250 matrix, and a gap weight of 16, 14, 12, 10, 8, 6, or 4 and a length weight of 1, 2, 3, 4, 5, or 6.

Additionally or alternatively, the protein sequences of the present invention can further be used as a "query sequence" to perform a search against public databases to, for example, identify related sequences. Such searches can be performed using the XBLAST program (version 2.0) of Altschul, et al., 1990 J.Mol. Biol. 215:403-10. BLAST protein searches can be performed with the XBLAST program, score = 50, wordlength = 3 to obtain amino acid sequences homologous to the antibody molecules of the invention. To obtain gapped alignments for comparison purposes, Gapped BLAST can be utilized as described in Altschul et al., 1997 Nucleic Acids Res. 25(17):3389-3402. When utilizing BLAST and Gapped BLAST programs, the default parameters of the respective programs (e.g., XBLAST and NBLAST) can be used. See http:Ilwww.ncbi.nhn.nih.gov.

Antibodies with conservative modifications

In certain embodiments, an antibody of the invention has a heavy chain variable region consist of CDR1, CDR2, and CDR3 sequences and a light chain variable region consisting of CDR1, CDR2, and CDR3 sequences, wherein one or more of these CDR sequences have specified amino acid sequences based on the antibodies described herein or conservative modifications thereof, and wherein the antibodies retain the desired functional properties of the anti-IL-13 antibodies of the invention. Accordingly, the invention provides an isolated monoclonal antibody, or antigen binding portion thereof, consisting of a heavy chain variable region consisting of CDR1, CDR2, and CDR3 sequences and a light chain variable region consisting of CDR1, CDR2, and CDR3 sequences, wherein: the heavy chain variable regions of CDR1 is sequences consisting of amino acid sequences selected from the group consisting of amino acid sequences of SEQ ID NOs: 6-7, and conservative modifications thereof; the heavy chain variable region of CDR2 is a sequence consisting of an amino acid sequence of SEQ ID NO: 8, and conservative modifications thereof; the heavy chain variable region of CDR3 is sequences consisting of amino acid sequences selected from the group consisting of amino acid sequences of SEQ ID NOs: 9-10, and conservative modifications thereof; the light chain variable regions of CDR1 is sequences consisting of amino acid sequences selected from the

group consisting of amino acid sequences of SEQ ID NOs: 16-18, and conservative modifications thereof; the light chain variable regions of CDR2 is a sequence consisting of an amino acid sequence of SEQ ID NO: 19, and conservative modifications thereof; the light chain variable regions of CDR3 is sequences consisting of amino acid sequences selected from the group consisting of amino acid sequences of SEQ ID NOs: 20-22, and conservative modifications thereof; the antibody specifically binds to IL-13; and the antibody inhibits IL-13 receptor binding preventing inflammatory mediator release.

In various embodiments, the antibody may exhibit one or more, two or more, or three or more of the functional properties listed discussed above. Such antibodies can be, for example, human antibodies, humanized antibodies or chimeric antibodies.

As used herein, the term "conservative sequence modifications" is intended to refer to amino acid modifications that do not significantly affect or alter the binding characteristics of the antibody containing the amino acid sequence. Such conservative modifications include amino acid substitutions, additions and deletions. Modifications can be introduced into an antibody of the invention by standard techniques known in the art, such as site-directed mutagenesis and PCR-mediated mutagenesis.

Conservative amino acid substitutions are ones in which the amino acid residue is replaced with an amino acid residue having a 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, asparagine, 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). Thus, one or more amino acid residues within the CDR regions of an antibody of the invention can be replaced with other amino acid residues from the same side chain family, and the altered antibody can be tested for retained function using the functional assays described herein.

Antibodies that bind to the same epitope as anti-IL-13 antibodies of the invention

In another embodiment, the invention provides antibodies that bind to the same epitope as do the various anti-IL-13 antibodies of the invention provided herein. Such additional 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 other antibodies of the invention in standard IL-13 binding assays. The ability of a test antibody to inhibit the binding of antibodies of the present invention to human IL-13 demonstrates that the test antibody can compete with that antibody for binding to human IL-13; such an antibody may, according to non-limiting theory, bind to the same or a related (e.g., a structurally similar or spatially proximal) epitope on human IL-13 as the antibody with which it competes. In a certain embodiment, the antibody that binds to the same epitope on human IL-13 as the antibodies of the present invention is a human monoclonal antibody. Such human monoclonal antibodies can be prepared and isolated as described in the Examples.

Engineered and modified antibodies

An antibody of the invention further can be prepared using an antibody having one or more of the V_H and/or V_L sequences shown herein as starting material to engineer a modified antibody, which modified antibody may have altered properties from the starting antibody. An antibody can be engineered by modifying one or more residues within one or both variable regions (i. e., V_H and/or V_L), for example within one or more CDR regions and/or within one or more framework regions. Additionally or alternatively, an antibody can be engineered by modifying residues within the constant region(s), for example to alter the effector function(s) of the antibody.

One type of variable region engineering that can be performed is CDR grafting. Antibodies interact with target antigens predominantly through amino acid residues that are located in the six heavy and light chain complementarity determining regions (CDRs). For this reason, the amino acid sequences within CDRs are more diverse between individual antibodies than sequences outside of CDRs. Because CDR sequences are responsible for most antibody-antigen interactions, it is possible to express recombinant antibodies that mimic the properties of specific naturally occurring antibodies by constructing expression vectors that include CDR sequences from the specific naturally occurring antibody grafted onto framework sequences from a different antibody with different properties (see, e.g., Riechmann, L. et al., 1998 Nature 332:323-327; Jones, P. et al., 1986 Nature 321:522-525; Queen, C. et al., 1989 Proc. Natl. Acad. See. U.S.A. 86:10029-10033; U.S. Patent No. 5,225,539 to winter, and U.S. Patent Nos. 5,530,101; 5,585,089; 5,693,762 and 6,180,370 to Queen et al.)

Accordingly, another embodiment of the invention pertains to an isolated monoclonal antibody, or antigen binding portion thereof, comprising a heavy chain variable region

comprising CDR1 sequences having an amino acid sequence selected from the group consisting of SEQ ID NOs: 6-7; CDR2 sequences having an amino acid sequence of SEQ ID NO: 8; CDR3 sequences having an amino acid sequence selected from the group consisting of SEQ ID NOs: 9-10, respectively; and a light chain variable region having CDR1 sequences having an amino acid sequence selected from the group consisting of SEQ ID NOs: 16-18; CDR2 sequences having an amino acid sequence of SEQ ID NO:19; and CDR3 sequences consisting of an amino acid sequence selected from the group consisting of SEQ ID NOs: 20-22, respectively. Thus, such antibodies contain the V_H and V_L CDR sequences of monoclonal antibodies, yet may contain different framework sequences from these antibodies.

Such framework sequences can be obtained from public DNA databases or published references that include germline antibody gene sequences. For example, germline DNA sequences for human heavy and light chain variable region genes can be found in the "VBase" human germline sequence database (available on the Internet at www.mrc-cpe.cam.ac.uk/vbase), as well as in 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 J. fol. Biol. 227:776-798; and Cox, J. P. L. et al., 1994 Eur. J Immunol. 24:827-836; the contents of each of which are expressly incorporated herein by reference.

An example of framework sequences for use in the antibodies of the invention are those that are structurally similar to the framework sequences used by selected antibodies of the invention, e.g., consensus sequences and/or framework sequences used by monoclonal antibodies of the invention. The V_H CDR1, 2 and 3 sequences, and the V_L CDR1, 2 and 3 sequences, can be grafted onto framework regions that have the identical sequence as that found in the germline immunoglobulin gene from which the framework sequence derive, or the CDR sequences can be grafted onto framework regions that contain one or more mutations as compared to the germline sequences. For example, it has been found that in certain instances it is beneficial to mutate residues within the framework regions to maintain or enhance the antigen binding ability of the antibody (see e.g., U.S. Patent Nos. 5,530,101; 5,585,089; 5,693,762 and 6,180,370 to Queen et al).

Another type of variable region modification is to mutate amino acid residues within the V_H and/or V_L CDR1, CDR2 and/or CDR3 regions to thereby improve one or more binding properties (e.g., affinity) of the antibody of interest, known as "affinity maturation." Site-directed mutagenesis or PCR-mediated mutagenesis can be performed to introduce the

mutation(s) and the effect on antibody binding, or other functional property of interest, can be evaluated in in vitro or in vivo assays as described herein and provided in the Examples. Conservative modifications (as discussed above) can be introduced. The mutations may be amino acid substitutions, additions or deletions. Moreover, typically no more than one, two, three, four or five residues within a CDR region are altered.

Accordingly, in another embodiment, the invention provides isolated anti-IL-13 monoclonal antibodies, or antigen binding portions thereof, consisting of a heavy chain variable region having: a V_H CDR1 region consisting of an amino acid sequence selected from the group having SEQ ID NOs: 6-7 or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NOs: 6-7; a V_H CDR2 region having an amino acid sequence of SEQ ID NO: 8, or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NO: 8; a V_H CDR3 region having an amino acid sequence selected from the group consisting of SEQ ID NOs: 9-10, or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NOs: 9-10; a V_L CDR1 region having an amino acid sequence selected from the group consisting of SEQ ID NOs: 16-18, or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NOs: 16-18; a V_L CDR2 region having an amino acid sequence of SEQ ID NO: 19, or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NO: 19; and a V_L CDR3 region having an amino acid sequence selected from the group consisting of SEQ ID NOs: 20-22, or an amino acid sequence having one, two, three, four or five amino acid substitutions, deletions or additions as compared to SEQ ID NOs: 20-22.

Engineered antibodies of the invention include those in which modifications have been made to framework residues within V_H and/or V_L, e.g. to improve the properties of the antibody. 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 identified by comparing the antibody framework sequences to the germline sequences from which the antibody is derived. To return the framework region sequences to their germline configuration, the

somatic mutations can be "backmutated" to the germline sequence by, for example, site-directed mutagenesis or PCR-mediated mutagenesis. Such "backmutated" antibodies are also intended to be encompassed by the invention.

Another type of framework 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 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 region, 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. Furthermore, an antibody of the invention may be chemically modified (e.g., one or more chemical moieties can be attached to the antibody) or be modified to alter its glycosylation, again to alter one or more functional properties of the antibody. Each of these embodiments is described in further detail below. The numbering of residues in the Fc region is that of the EU index of Kabat.

In one embodiment, the hinge region of CH1 is modified such that the number of cysteine residues in the hinge region is altered, e.g., increased or decreased. This approach is described further in U.S. Patent No. 5,677,425 by Bodmer et al. The number of cysteine residues in the hinge region of CH1 is altered to, for example, facilitate assembly of the light and heavy chains or to increase or decrease the stability of the antibody.

In another embodiment, the Fc hinge region of an antibody is mutated to decrease the biological half-life of the antibody. More specifically, one or more amino acid mutations are introduced into the CH2-CH3 domain interface region of the Fc-hinge fragment such that the antibody has impaired Staphylococcyl protein A (SpA) binding relative to native Fc-hinge domain SpA binding. This approach is described in further detail in U.S. Patent No. 6,165,745 by Ward et al.

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: T252L, T254S, T256F, as described in U.S. Patent No. 6,277,375 to Ward. Alternatively, to increase the biological half life, the antibody can be altered within the CH1 or CL region to contain a salvage receptor binding epitope taken from two loops of a CH2

domain of an Fc region of an IgG, as described 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 functions of the antibody. For example, one or more amino acids can be replaced with a different amino acid residue such that the antibody has an altered affinity for an effector ligand but retains the antigen-binding ability of the parent antibody. The effector ligand to which affinity is altered can be, for example, an Fc receptor or the C1 component of complement. This approach is described in further detail in U.S. Patent Nos. 5,624,821 and 5,648,260, both by Winter et al.

In another embodiment, one or more amino acids selected from amino acid residues can be replaced with a different amino acid residue such that the antibody has altered C1q binding and/or reduced or abolished complement dependent cytotoxicity (CDC). This approach is described in further detail in U.S. Patent Nos. 6,194,551 by Idusogie et at.

In another embodiment, one or more amino acid residues are altered to thereby alter the ability of the antibody to fix complement. This approach is described further in PCT Publication WO 94/29351 by Bodmer et al.

In yet another embodiment, the Fc region is modified to increase the ability of the antibody to mediate antibody dependent cellular cytotoxicity (ADCC) and/or to increase the affinity of the antibody for an Fcγ receptor by modifying one or more amino acids. This approach is described further in PCT Publication WO 00/42072 by Presta. Moreover, the binding sites on human IgG1 for FcγRI, FcγRII, FcγRIII and FcRn have been mapped and variants with improved binding have been described (see Shields, R.L. et al., 2001 J. Biol. Chen. 276:6591-6604).

In still another embodiment, the glycosylation of an antibody is modified. For example, an aglycoslated 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 eliminate glycosylation at that site. Such aglycosylation may increase the affinity of the antibody for antigen. Such an approach is described in further detail in U.S. Patent Nos. 5,714,350 and 6,350,861 by Co et al.

Additionally or alternatively, an antibody can be made 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. 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 invention to thereby produce an antibody with altered glycosylation. For example, EP 1,176,195 by Hang et al. describes a cell line with a functionally disrupted FUT8 gene, which encodes a fucosyl transferase, such that antibodies expressed in such a cell line exhibit hypofucosylation. PCT Publication WO 03/035835 by Presta describes a variant CHO cell line, Lecl3 cells, with reduced ability to attach fucose to Asn(297)-linked carbohydrates, also resulting in hypofucosylation of antibodies expressed in that host cell (see also Shields, R.L. et al., 2002 J. Biol. Chem. 277:26733-26740). PCT Publication WO 99/54342 by Umana et al. describes cell lines engineered to express glycoprotein-modifying glycosyl transferases (e.g., beta(1,4)-N acetylglucosaminyltransferase III (GnTIII)) such that antibodies expressed in the engineered cell lines exhibit increased bisecting GlcNac structures which results in increased ADCC activity of the antibodies (see also Umana et al., 1999 Nat. Biotech. 17:176-180).

Another modification of the antibodies herein that is contemplated by the invention is pegylation. An antibody can be pegylated to, for example, increase the biological (e.g., serum) half-life of the antibody. To pegylate an antibody, the antibody, or fragment thereof, typically is reacted with polyethylene glycol (PEG), such as a reactive ester or aldehyde derivative of PEG, under conditions in which one or more PEG groups become attached to the antibody or antibody fragment. The pegylation can be carried out by an acylation reaction or an alkylation reaction with a reactive PEG molecule (or an analogous reactive water-soluble polymer). As used herein, the term "polyethylene glycol" is intended to encompass any of the forms of PEG that have been used to derivatize other proteins, such as mono (C1-C10) alkoxy- or aryloxy-polyethylene glycol or polyethylene glycol-maleimide. In certain embodiments, the antibody to be pegylated is an aglycosylated antibody. Methods for pegylating proteins are known in the art and can be applied to the antibodies of the invention. See for example, EP 0 154 316 by Nishimura et al. and EP 0 401 384 by Ishikawa et al.

Methods of engineering antibodies

As discussed above, the anti- IL-13 antibodies having V_H and V_L sequences shown herein can be used to create new anti-IL-13 antibodies by modifying the V_H and/or V_L

sequences, or the constant region(s) attached thereto. Thus, in another aspect of the invention, the structural features of an anti-IL-13 antibody of the invention are used to create structurally related anti-IL-13 antibodies that retain at least one functional property of the antibodies of the invention, such as binding to human IL-13 and also inhibiting one or more functional properties of IL-13 (e.g., receptor binding, inhibition of mediator release).

For example, one or more CDR regions of the antibodies of the present invention, or mutations thereof, can be combined recombinantly with known framework regions and/or other CDRs to create additional, recombinantly-engineered, anti-IL-13 antibodies of the invention, as discussed above. Other types of modifications include those described in the previous section. The starting material for the engineering method is one or more of the V_H and/or V_L sequences provided herein, or one or more CDR regions thereof. To create the engineered antibody, it is not necessary to actually prepare (i.e., express as a protein) an antibody having one or more of the V_H and/or V_L sequences provided herein, or one or more CDR regions thereof. Rather, the information contained in the sequence(s) is used as the starting material to create a "second generation" sequence(s) derived from the original sequence(s) and then the "second generation" sequence(s) is prepared and expressed as a protein.

Accordingly, in another embodiment, the invention provides a method for preparing an anti-IL-13 antibody consisting of: a heavy chain variable region antibody sequence having a CDR1 sequence selected from the group consisting of SEQ ID NOs: 6-7, a CDR2 sequence of SEQ ID NO: 8 and/or a CDR3 sequence selected from the group consisting of SEQ ID NOs: 9-10; and a light chain variable region antibody sequence having a CDR1 sequence selected from the group consisting of SEQ ID NOs: 16-18, a CDR2 sequence of SEQ ID NO: 19 and/or a CDR3 sequence selected from the group consisting of SEQ ID NOs: 20-22; altering at least one amino acid residue within the heavy chain variable region antibody sequence and/or the light chain variable region antibody sequence to create at least one altered antibody sequence; and expressing the altered antibody sequence as a protein.

Standard molecular biology techniques can be used to prepare and express the altered antibody sequence. The antibody encoded by the altered antibody sequence(s) is one that retains one, some or all of the functional properties of the anti-IL-13 antibodies described herein, which functional properties include, but are not limited to, specifically binding to human IL-13; and the antibody exhibits at least one of the following functional properties: the antibody inhibits binding of IL-13 protein to the IL-13 receptor, or the antibody inhibits IL-

13 receptor binding preventing or ameliorating an inflammatory, fibrotic or allergic condition, particularly an inflammatory or obstructive airways disease, or the antibody inhibits IL-13 receptor binding thereby preventing or ameliorating asthma.

The altered antibody may exhibit one or more, two or more, or three or more of the functional properties discussed above.

The functional properties of the altered antibodies can be assessed using standard assays available in the art and/or described herein, such as those set forth in the Examples (e.g., ELISAs).

In certain embodiments of the methods of engineering antibodies of the invention, mutations can be introduced randomly or selectively along all or part of an anti-IL-13 antibody coding sequence and the resulting modified anti-IL-13 antibodies can be screened for binding activity and/or other functional properties as described herein. Mutational methods have been described in the art. For example, PCT Publication WO 02/092780 by Short describes methods for creating and screening antibody mutations using saturation mutagenesis, synthetic ligation assembly, or a combination thereof. Alternatively, PCT Publication WO 03/074679 by Lazar et al. describes methods of using computational screening methods to optimize physiochemical properties of antibodies.

Nucleic acid molecules encoding antibodies of the invention

Another aspect of the invention pertains to nucleic acid molecules that encode the antibodies of the invention. The nucleic acids may be present in whole cells, in a cell lysate, or may be nucleic acids in a partially purified or substantially pure form. A nucleic acid is "isolated" or "rendered substantially pure" when purified away from other cellular components or other contaminants, e.g., other cellular nucleic acids or proteins, by standard techniques, including alkaline/SDS treatment, CsCl banding, column chromatography, agarose gel electrophoresis and others well known in the art. See, F. Ausubel, et al., ed. 1987 Current Protocols in Molecular Biology, Greene Publishing and Wiley Interscience, New York. A nucleic acid of the invention can be, for example, DNA or RNA and may or may not contain intronic sequences. In an embodiment, the nucleic acid is a cDNA molecule. The nucleic acid may be present in a vector such as a phage display vector, or in a recombinant plasmid vector.

Nucleic acids of the invention can be obtained using standard molecular biology techniques. For antibodies expressed by hybridomas (e.g., hybridomas prepared from transgenic mice carrying human immunoglobulin genes as described further below), 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 phage display techniques), nucleic acid encoding the antibody can be recovered from various phage clones that are members of the library.

Once DNA fragments encoding V_H and V_L segments are obtained, these DNA fragments can be further manipulated by standard recombinant DNA techniques, for example to convert the variable region genes to full-length antibody chain genes, to Fab fragment genes or to an scFv gene. In these manipulations, a V_L- or V_H-encoding DNA fragment is operatively linked to another DNA molecule, or to a fragment encoding another protein, such as an antibody constant region or a flexible linker. The term "operatively linked", as used in this context, is intended to mean that the two DNA fragments are joined in a functional manner, for example, such that the amino acid sequences encoded by the two DNA fragments remain in-frame, or such that the protein is expressed under control of a desired promoter.

The isolated DNA encoding the V_H region can be converted to a full-length heavy chain gene by operatively linking the V_H-encoding DNA to another DNA molecule encoding heavy chain constant regions (CH1, CH2 and CH3). The sequences of human heavy chain constant region genes are known in the art (see e.g., Kabat, E. A., el al., 1991 Sequences of Proteins of Immunological Interest, Fifth Edition, U.S. Department of Health and Human Services, NIH Publication No. 91-3242) and DNA fragments encompassing these regions can be obtained by standard PCR amplification. The heavy chain constant region can be an IgG1, IgG2, IgG3, IgG4, IgA, IgE, IgM or IgD constant region. For a Fab fragment heavy chain gene, the V_H-encoding DNA can be operatively linked to another DNA molecule encoding only the heavy chain CH1 constant region.

The isolated DNA encoding the V_L region can be converted to a full-length light chain gene (as well as to a Fab light chain gene) by operatively linking the V_L-encoding DNA to another DNA molecule encoding the light chain constant region, CL. The sequences of human light chain constant region genes are known in the art (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) and DNA fragments encompassing these regions can be obtained by standard PCR amplification. The light chain constant region can be a kappa or a lambda constant region.

To create an scFv gene, the V_H- and V_L-encoding DNA fragments are operatively linked to another fragment encoding a flexible linker, e.g., encoding the amino acid sequence $(Gly4\text{-}Ser)_3$, such that the V_H and V_L sequences can be expressed as a contiguous single-

chain protein, with the V_L and V_H regions joined by the flexible linker (see e.g., Bird et al., 1988 Science 242:423-426; Huston et at., 1988 Proc. Natl. Acad. Sci. USA 85:5879-5883; McCafferty et al., 1990 Nature 348:552-554).

Production of monoclonal antibodies of the invention

Monoclonal antibodies (mAbs) can be produced by a variety of techniques, including conventional monoclonal antibody methodology e.g., the standard somatic cell hybridization technique of Kohler and Milstein, 1975 Nature 256: 495. Many techniques for producing monoclonal antibody can be employed e.g., viral or oncogenic transformation of B lymphocytes.

An animal system for preparing hybridomas is the murine system. Hybridoma production in the mouse is a well established procedure. Immunization protocols and techniques for isolation of immunized splenocytes for fusion are known in the art. Fusion partners (e.g., murine myeloma cells) and fusion procedures are also known.

Chimeric or humanized antibodies of the present invention can be prepared based on the sequence of a murine monoclonal antibody prepared as described above. DNA encoding the heavy and light chain immunoglobulins can be obtained from the murine hybridoma of interest and engineered to contain non-murine (e.g.,. human) immunoglobulin sequences using standard molecular biology techniques. For example, to create a chimeric antibody, the murine variable regions can be linked to human constant regions using methods known in the art (see e.g., U.S. Patent No. 4,816,567 to Cabilly et al.). To create a humanized antibody, the murine CDR regions can be inserted into a human framework using methods known in the art (see e.g., U.S. Patent No. 5,225,539 to Winter, and U.S. Patent Nos. 5,530,101; 5,585,089; 5,693,762 and ,6;180;370 to.Queen.et al.

In a certain embodiment, the antibodies of the invention are human monoclonal antibodies. Such human monoclonal antibodies directed against IL-13 can be generated using transgenic or transchromosomic mice carrying parts of the human immune system rather than the mouse system. These transgenic and transchromosomic mice include mice referred to herein as HuMAb mice and KM mice, respectively, and are collectively referred to herein as "human Ig mice."

The HuMAb mouse® (Medarex, Inc.) contains human immunoglobulin gene miniloci that encode un-rearranged human heavy (μ and γ) and κ light chain immunoglobulin sequences, together with targeted mutations that inactivate the endogenous μ and κ chain loci (see e.g., Lonberg, et al., 1994 Nature 368(6474): 856-859). Accordingly, the mice exhibit

reduced expression of mouse IgM or κ, and in response to immunization, the introduced human heavy and light chain transgenes undergo class switching and somatic mutation to generate high affinity human IgGκ monoclonal (Lonberg, N. et al., 1994 supra; reviewed in Lonberg, N., 1994 Handbook of Experimental Pharmacology 113:49-101; Lonberg, N. and Huszar, D., 1995 Intern. Rev. Immunol.13: 65-93, and Harding, F. and Lonberg, N., 1995 Ann. N. Y. Acad. Sci. 764:536-546). The preparation and use of HuMAb mice, and the genomic modifications carried by such mice, is further described in Taylor, L. et al., 1992 Nucleic Acids Research 20:6287-6295; Chen, J. et at., 1993 International Immunology 5: 647-656; Tuaillon et al., 1993 Proc. Natl. Acad. Sci. USA 94:3720-3724; Choi et al., 1993 Nature Genetics 4:117-123; Chen, J. et al., 1993 EMBO J. 12: 821-830; Tuaillon et al., 1994 J. Immunol. 152:2912-2920; Taylor, L. et al., 1994 International Immunology 579-591; and Fishwild, D. et al., 1996 Nature Biotechnology 14: 845-851, the contents of all of which are hereby specifically incorporated by reference in their entirety. See further, 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; 5,874,299; and 5,770,429; all to Lonberg and Kay; U.S. Patent No. 5,545,807 to Surani et al.; PCT Publication Nos. WO 92103918, WO 93/12227, WO 94/25585, WO 97113852, WO 98/24884 and WO 99/45962, all to Lonberg and Kay; and PCT Publication No. WO 01/14424 to Korman et al.

In another embodiment, human antibodies of the invention can be raised using a mouse that carries human immunoglobulin sequences on transgenes and transchomosomes such as a mouse that carries a human heavy chain transgene and a human light chain transchromosome. Such mice, referred to herein as "KM mice", are described in detail in PCT Publication WO 02/43478 to Ishida et al.

Still further, alternative transgenic animal systems expressing human immunoglobulin genes are available in the art and can be used to raise anti-IL-13 antibodies of the invention. For example, an alternative transgenic system referred to as the Xenomouse (Abgenix, Inc.) can be used; such mice are described in, for example, U.S. Patent Nos. 5,939,598; 6,075,181; 6,114,598; 6, 150,584 and 6,162,963 to Kucherlapati et al.

Moreover, alternative transchromosomic animal systems expressing human immunoglobulin genes are available in the art and can be used to raise anti-IL-13 antibodies of the invention. For example, mice carrying both a human heavy chain transchromosome and a human light chain tranchromosome, referred to as "TC mice" can be used; such mice are described in Tomizuka et al., 2000 Proc. Natl. Acad. Sci. USA 97:722-727. Furthermore, cows carrying human heavy and light chain transchromosomes have been described in the art

(Kuroiwa et al., 2002 Nature Biotechnology 20:889-894) and can be used to raise anti-IL-13 antibodies of the invention.

Human monoclonal antibodies of the invention can also be prepared using phage display methods for screening libraries of human immunoglobulin genes. Such phage display methods for isolating human antibodies are established in the art. See for example: U.S. Patent Nos. 5,223,409; 5,403,484; and 5,571,698 to Ladner et al.; U.S. Patent Nos. 5,427,908 and 5,580,717 to Dower et al.; U.S. Patent Nos. 5,969,108 and 6,172,197 to McCafferty et al.; and U.S. Patent Nos. 5,885,793; 6,521,404; 6,544,731; 6,555,313; 6,582,915 and 6,593,081 to Griffiths et al.

Human monoclonal antibodies of the invention can also be prepared using SCID mice into which human immune cells have been reconstituted such that a human antibody response can be generated upon immunization. Such mice are described in, for example, U.S. Patent Nos. 5,476,996 and 5,698,767 to Wilson et al.

Generation of human monoclonal antibodies against IL-13

Purified recombinant human (hr) IL-13 conjugated to Pan DR T helper Epitopes (PADRE), is used as the antigen. Fully human monoclonal antibodies to IL-13 are prepared using HCo7 strains of HuMab transgenic mice which express human antibody genes. In this mouse strain, the endogenous mouse kappa light chain gene can be homozygously disrupted as described in Chen et al., 1993 EMBO J.12:811-820 and the endogenous mouse heavy chain gene can be homozygously disrupted as described in Example 1 of PCT Publication WO 01109187. This mouse strain carries a human kappa light chain transgene, KCo5, as described in Fishwild et al., 1996 Nature Biotechnology 14:845-851 and the HCo7 human heavy chain transgene as described in U.S. Patent Nos. 5,545,806; 5,625,825; and 5,545,807.

To generate fully human monoclonal antibodies to IL-13 of the invention, HuMab mice are immunized with a mixture of purified recombinant IL-13 derived from HEK-EBNA/PADRE conjugate (42ug/mouse) and Quil A (15ug/mouse, Accurate Chemical). General immunization schemes for HuMab mice are described in Lonberg, N. et al., 1994 Nature 368(6474): 856-859; Fishwild, D. et al., 1996 Nature Biotechnology 14:845-851 and PCT Publication WO 98/24884. Transgenic mice are immunized either intravenously (IV), or subcutaneously (SC) between day 1-71. Mice are boosted intravenously with antigen (without adjuvant) 2 days before sacrifice and removal of the spleen. RNA was isolated from spleens using the Nucleospin RNA II isolation kit (BD Biosciences/Clontech). The RNA was used to generate a phage display library of randomly assorted H and L chain variable domains in a

Fab phage display vector as described in US Patent 6,794,132. The phage display library was subjected to five rounds of selection using biotinylated hrIL-13 in a solution-phase equilibrium binding protocol as described in the patent. The first four rounds of selection employed hrIL-13 at 10^{-8} M and the last round of selection employed hrIL-13 at 10^{-9} M. The final signal to noise ratio determined by counting pfu's recovered in the presence of antigen divided by pfu's recovered in the absence of antigen was 37 for this library, indicating that greater than 90% of the phage selected were expressing antibodies that bound hrIL-13. The phage display library was then subcloned into a plasmid vector for the expression of soluble Fab as described in US Patent 6,794,132.

Generation of transfectomas producing monoclonal antibodies

Antibodies of the invention also can be produced in a host cell transfectoma using, for example, a combination of recombinant DNA techniques and gene transfection methods as is well known in the art (e.g., Morrison, S. (1985) Science 229:1202).

For example, to express the antibodies, or antibody fragments thereof, DNAs encoding partial or full-length light and heavy chains, can be obtained by standard molecular biology techniques (e.g., PCR amplification or cDNA cloning using a hybridoma that expresses the antibody of interest) and the DNAs can be inserted into expression vectors such that the genes are operatively linked to transcriptional and translational control sequences. In this context, the term "operatively linked" is intended to mean that an antibody gene is ligated into a vector such that transcriptional and translational control sequences within the vector serve their intended function of regulating the transcription and translation of the antibody gene. The expression vector and expression control sequences are chosen to be compatible with the expression host cell used. 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 that the V_H segment is operatively linked to the CH segment(s) within the vector and the V_L segment is operatively linked to the CL segment within the vector. Additionally or alternatively, the recombinant expression 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 immunoglobulin signal peptide or a heterologous signal peptide (i.e., a signal peptide from a non-immunoglobulin protein).

In addition to the antibody chain genes, the recombinant expression vectors of the invention carry regulatory sequences that control the expression of the antibody chain genes in a host cell. The term "regulatory sequence" is intended to include promoters, enhancers and other expression control elements (e.g., polyadenylation signals) that control the transcription or translation of the antibody chain genes. Such regulatory sequences are described, for example, in Goeddel (Gene Expression Technology. Methods in Enzymology 185, Academic Press, San Diego, CA 1990). It will be appreciated by those skilled in the art that the design of the expression vector, including the selection of regulatory sequences, may depend on such factors as the choice of the host cell to be transformed, the level of expression of protein desired, etc. Regulatory sequences for mammalian host cell expression include viral elements that direct high levels of protein expression in mammalian cells, such as promoters and/or enhancers derived from cytomegalovirus (CMV), Simian Virus 40 (SV40), adenovirus (e.g., the adenovirus major late promoter (AdMLP)), and polyoma. Alternatively, nonviral regulatory sequences may be used, such as the ubiquitin promoter or P-globin promoter. Still further, regulatory elements composed of sequences from different sources, such as the SRa promoter system, which contains sequences from the SV40 early promoter and the long terminal repeat of human T cell leukemia virus type 1 (Takebe, Y. et al., 1988 Mol. Cell. Biol. 8:466-472).

In addition to the antibody chain genes and regulatory sequences, the recombinant expression vectors of the invention may carry additional sequences, such as sequences that regulate replication of the vector in host cells (e.g., origins of replication) and selectable marker genes. The selectable marker gene facilitates selection of host cells into which the vector has been introduced (see, e.g., U.S. Pat. Nos. 4,399,216, 4,634,665 and 5,179,017, all by Axel et al.). For example, typically the selectable marker gene confers resistance to drugs, such as G418, hygromycin or methotrexate, on a host cell into which the vector has been introduced. Selectable marker genes include the dihydrofolate reductase (DHFR) gene (for use in dhfr- host cells with methotrexate selection/amplification) and the neo gene (for G418 selection).

For expression of the light and heavy chains, the expression vector(s) encoding the heavy and light chains is transfected into a host cell by standard techniques. The various

forms of the term "transfection" are intended to encompass a wide variety of techniques commonly used for the introduction of exogenous DNA into a prokaryotic or eukaryotic host cell, e.g., electroporation, calcium-phosphate precipitation, DEAE-dextran transfection and the like. It is theoretically possible to express the antibodies of the invention in either prokaryotic or eukaryotic host cells. Expression of antibodies in eukaryotic cells, in particular mammalian host cells, is discussed because such eukaryotic cells, and in particular mammalian cells, are more likely than prokaryotic cells to assemble and secrete a properly folded and immunologically active antibody. Prokaryotic expression of antibody genes has been reported to be ineffective for production of high yields of active antibody (Boss, M. A. and Wood, C. R., 1985 Immunology Today 6:12-13).

Mammalian host cells for expressing the recombinant antibodies of the invention include Chinese Hamster Ovary (CHO cells) (including dhfr- CHO cells, described Urlaub and Chasin, 1980 Proc. Natl. Acad. Sci. USA 77:4216-4220 used with a DH FR selectable marker, e.g., as described in R.J. Kaufman and P.A. Sharp, 1982 Mol. Biol. 159:601-621, NSO myeloma cells, COS cells and SP2 cells. When recombinant expression vectors encoding antibody genes are introduced into mammalian host cells, the antibodies are produced by culturing the host cells for a period of time sufficient to allow for expression of the antibody in the host cells or secretion of the antibody into the culture medium in which the host cells are grown. Antibodies can be recovered from the culture medium using standard protein purification methods.

Immunoconjugates

In another aspect, the present invention features an anti-IL-13 antibody, or a fragment thereof, conjugated to a therapeutic moiety, such as a cytotoxin, a drug (e.g., an immunosuppressant) or a radiotoxin. Such conjugates are referred to herein as "immunoconjugates". Immunoconjugates that include one or more cytotoxins are referred to as "immunotoxins." A cytotoxin or cytotoxic agent includes any agent that is detrimental to (e.g., kills) cells. Examples include taxon, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, t. colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1 - dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or homologs thereof. Therapeutic agents also include, for example, antimetabolites (e.g., methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-fluorouracil decarbazine), ablating agents (e.g., mechlorethamine, thioepa chloraxnbucil,

meiphalan, carmustine (BSNU) and lomustine (CCNU), cyclothosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin, anthracyclines (e.g., daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (e.g., dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC)), and anti-mitotic agents (e.g., vincristine and vinblastine).

Other examples of therapeutic cytotoxins that can be conjugated to an antibody of the invention include duocarmycins, calicheamicins, maytansines and auristatins, and derivatives thereof. An example of a calicheamicin antibody conjugate is commercially available (MylotargTm; Wyeth-Ayerst).

Cytotoxins can be conjugated to antibodies of the invention using linker technology available in the art. Examples of linker types that have been used to conjugate a cytotoxin to an antibody include, but are not limited to, hydrazones, thioethers, esters, disulfides and peptide-containing linkers. A linker can be chosen that is, for example, susceptible to cleavage by low pH within the lysosomal compartment or susceptible to cleavage by proteases, such as proteases preferentially expressed in tumor tissue such as cathepsins (e.g., cathepsins B, C, D).

For further discussion of types of cytotoxins, linkers and methods for conjugating therapeutic agents to antibodies, see also Saito, G. et al., 2003 Adv. Drug Deliv. Rev. 55:199-215; Trail, P.A. et al., 2003 Cancer Immunol. Immunother. 52:328-337; Payne, G., 2003 Cancer Cell 3:207-212; Allen, T.M., 2002 Nat. Rev. Cancer 2:750-763; Pastan, I. and Kreitman, R. J., 2002 Curr. Opin. Investig. Drugs 3:1089-1091; Senter, P.D. and Springer, C.J., 2001 Adv. Drug Deliv. Rev. 53:247-264.

Antibodies of the present invention also can be conjugated to a radioactive isotope to generate cytotoxic radiopharmaceuticals, also referred to as radioimmunoconjugates. Examples of radioactive isotopes that can be conjugated to antibodies for use diagnostically or therapeutically include, but are not limited to, iodine^{131}, indium^{111}, yttrium^{90}, and lutetium^{177}. Method for preparing radioimmunconjugates are established in the art. Examples of radioimmunoconjugates are commercially available, including Zevalin™ (DEC Pharmaceuticals) and Bexxar™ (Corixa Pharmaceuticals), and similar methods can be used to prepare radioimmunoconjugates using the antibodies of the invention.

The antibody conjugates of the invention can be used to modify a given biological response, and the drug moiety is not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety may be a protein or polypeptide possessing a desired biological activity. Such proteins may include, for example, an enzymatically active

toxin, or active fragment thereof, such as abrin, ricin A, pseudomonas exotoxin, or diphtheria toxin; a protein such as tumor necrosis factor or interferon-γ; or, biological response modifiers such as, for example, lymphokines, interleukin-1 ("IL-1"), interleukin-2 ("IL-2"), interleukin-6 ("IL-6"), granulocyte macrophage colony stimulating factor ("GM-CSF"), granulocyte colony stimulating factor ("G-CSF"), or other growth factors.

Techniques for conjugating such therapeutic moiety to antibodies are well known, see, e.g., Amon et al., "Monoclonal Antibodies For Immunotargeting Of Drugs In Cancer Therapy", in Monoclonal Antibodies And Cancer Therapy, Reisfeld et al. (eds.), pp. 243-56 (Alan R. Liss, Inc. 1985); Hellstrom et at., "Antibodies For Drug Delivery", in Controlled Drug Delivery (2nd Ed.), Robinson et al. (eds.), pp. 623-53 (Marcel Dekker, Inc. 1987); Thorpe, "Antibody Carriers Of Cytotoxic Agents In Cancer Therapy: A Review", in Monoclonal Antibodies '84: Biological And Clinical Applications, Pinchera et al. (eds.), pp. 475-506 (1985); "Analysis, Results, And Future Prospective Of The Therapeutic Use Of Radiolabeled Antibody In Cancer Therapy", in Monoclonal Antibodies For Cancer Detection And Therapy, Baldwin et al. (eds.), pp. 303-16 (Academic Press 1985), and Thorpe et al., "The Preparation And Cytotoxic Properties Of Antibody-Toxin Conjugates", Inmunol. Rev., 62:119-58 (1982).

Bispecific molecules

In another aspect, the present invention features bispecific molecules comprising an anti-IL-13 antibody, or a fragment thereof, of the invention. An antibody of the invention, or antigen-binding portions thereof, can be derivatized or linked to another functional molecule, e.g., another peptide or protein (e.g., another antibody or ligand for a receptor) to generate a bispecific molecule that binds to at least two different binding sites or target molecules. The antibody of the invention may in fact be derivatized or linked to more than one other functional molecule to generate multi-specific molecules that bind to more than two different binding sites and/or target molecules; such multi-specific molecules are also intended to be encompassed by the term "bispecific molecule" as used herein. To create a bispecific molecule of the invention, an antibody of the invention can be functionally linked (e.g., by chemical coupling, genetic fusion, noncovalent association or otherwise) to one or more other binding molecules, such as another antibody, antibody fragment, peptide or binding mimetic, such that a bispecific molecule results.

Accordingly, the present invention includes bispecific molecules comprising at least one first binding specificity for IL-13 and a second binding specificity for a second target

epitope. For example, the second target epitope is an Fc receptor, e.g., human FcγRI (CD64) or a human Fcα receptor (CD89). Therefore, the invention includes bispecific molecules capable of binding both to FcγR, FcαR or FcεR expressing effector cells (e.g., monocytes, macrophages or polymorphonuclear cells (PMNs), and to target cells expressing IL-13. These bispecific molecules target IL-13 expressing cells to effector cell and trigger Fc receptor-mediated effector cell activities, such as phagocytosis of an IL-13 expressing cells, antibody dependent cell-mediated cytotoxicity (ADCC), cytokine release, or generation of superoxide anion.

Additionally, for the invention in which the bispecific molecule is multi-specific, the molecule can further include a third binding specificity, in addition to an anti-Fc binding specificity and an anti-IL-13 binding specificity. For example, the third binding specificity could be an anti-enhancement factor (EF) portion, e.g., a molecule which binds to a surface protein involved in cytotoxic activity and thereby increases the immune response against the target cell. The "anti-enhancement factor portion" could be an antibody, functional antibody fragment or a ligand that binds to a given molecule, e.g., an antigen or a receptor, and thereby results in an enhancement of the effect of the binding determinants for the Fc receptor or target cell antigen.

The "anti-enhancement factor portion" can bind an Fc receptor or a target cell antigen. Alternatively, the anti-enhancement factor portion could bind to an entity that is different from the entity to which the first and second binding specificities bind. For example, the anti-enhancement factor portion can bind a cytotoxic T-cell (e.g. by CD2, CD3, CD8, CD28, CD4, CD44, ICAM-1 or other immune cell that results in an increased immune response against the target cell).

In one embodiment, the bispecific molecules of the invention comprise as a binding specificity at least one antibody, or an antibody fragment thereof, including, e.g., an Fab, Fab', $F(ab')_2$, Fv, or a single chain Fv. The antibody may also be a light chain or heavy chain dimer, or any minimal fragment thereof such as a Fv or a single chain construct as described in Ladner et al. U.S. Patent No. 4,946,778, the contents of which is expressly incorporated by reference.

In one embodiment, the binding specificity for an Fcγ receptor is provided by a monoclonal antibody, the binding of which is not blocked by human immunoglobulin G (IgG). As used herein, the term "IgG receptor" refers to any of the eight γ-chain genes located on chromosome 1. These genes encode a total of twelve transmembrane or soluble receptor isoforms which are grouped into three Fγ receptor classes: FcγRI (CD64), FcγRII(CD32), and

FcγRIII (CD 16). In another embodiment, the Fcγ receptor is a human high affinity FcγRI. The human FcγRI is a 72 kDa molecule, which shows high affinity for monomeric IgG (10^8 - 10^9 M^{-1}).

The production and characterization of certain anti-Fcγ monoclonal antibodies are described by Fanger et at. in PCT Publication WO 88/00052 and in U.S. Patent No. 4,954,617, the teachings of which are fully incorporated by reference herein. These antibodies bind to an epitope of FcγRI, FcγRII or FcγRIII at a site which is distinct from the Fcγ binding site of the receptor and, thus, their binding is not blocked substantially by physiological levels of IgG. Specific anti-FcγRI antibodies useful in this invention are mAb 22, mAb 32, mAb 44, mAb 62 and mAb 197. The hybridoma producing mAb 32 is available from the American Type Culture Collection, ATCC Accession No. HB9469. In other embodiments, the anti-Fcγ receptor antibody is a humanized form of monoclonal antibody 22 (H22). The production and characterization of the H22 antibody is described in Graziano, R.F. et al., 1995 J. Immunol 155 (10): 4996-5002 and PCT Publication WO 94/10332. The 1122 antibody producing cell line was deposited at the American Type Culture Collection under the designation HA022CL1 and has the accession no. CRL 11177.

In still other embodiments, the binding specificity for an Fc receptor is provided by an antibody that binds to a human IgA receptor, e.g., an Fc-alpha receptor (FcαRI (CD89), the binding of which does not have to be blocked by human imrnunoglobulin A (IgA). The term "IgA receptor" is intended to include the gene product of one a gene (FcαRI) located on chromosome 19. This gene is known to encode several alternatively spliced transmembrane isoforms of 55 to 110 kDa. FcαRI (CD89) is constitutively expressed on monocytes/macrophages, eosinophilic and neutrophilic granulocytes, but not on non-effector cell populations. FcαRI has medium affinity (5 x 10^7 M^{-1}) for both IgAl and IgA2, which is increased upon exposure to cytokines such as G-CSF or GM-CSF (Morton, H.C. et al., 1996 Critical Reviews in Immunology 116:423-440). Four FcαRI-specific monoclonal antibodies, identified as A3, A59, A62 and A77, which bind FcαRI outside the IgA ligand binding domain, have been described (Monteiro, R.C. et al., 1992 J. Immunol. 148:1764).

FcαRI and FcγRI are trigger receptors for use in the bispecific molecules of the invention because they are expressed primarily on immune effector cells, e.g., monocytes, PMNs, macrophages and dendritic cells; expressed at high levels (e.g., 5,000-100,000 per cell); mediators of cytotoxic activities (e.g., ADCC, phagocytosis); mediate enhanced antigen presentation of antigens, including self-antigens, targeted to them.

Other antibodies which can be employed in the bispecific molecules of the invention are murine, chimeric and humanized monoclonal antibodies.

The bispecific molecules of the present invention can be prepared by conjugating the constituent binding specificities, e.g., the anti-FcR and anti-IL-13 binding specificities, using methods known in the art. For example, each binding specificity of the bispecific molecule can be generated separately and then conjugated to one another. When the binding specificities are proteins or peptides, a variety of coupling or cross-linking agents can be used for covalent conjugation. Examples of cross-linking agents include protein A, carbodiimide, N-succinimidyl-S-acetyl-thioacetate (SATA), 5,5'-dithiobis(2-nitrobenzoic acid) (DTNB), o-phenylenedimaleimide (oPDM), N-succinimidyl-3-(2-pyridyldithio)propionate (SPDP), and sulfosuccinimidyl 4-(N-maleimidomethyl) cyclohaxane-l-carboxylate (sulfo-SMCC) (see e.g., Karpovsky et al., 1984 J. Exp. Med. 160:1686; Liu, MA et al., 1985 Proc. Natl. Acad. Sci. USA 82:8648). Other methods include those described in Paulus, 1985 Behring Ins. Mitt. No. 78,118-132; Brennan et al., 1985 Science 229:81-83), and Glennie et al., 1987 J. Immunol. 139: 2367-2375). Conjugating agents are SATA and sulfo-SMCC, both available from Pierce Chemical Co. (Rockford, IL).

When the binding specificities are antibodies, they can be conjugated by sulfhydryl bonding of the C-terminus hinge regions of the two heavy chains. In a particularly embodiment, the hinge region is modified to contain an odd number of sulfhydryl residues, for example one, prior to conjugation.

Alternatively, both binding specificities can be encoded in the same vector and expressed and assembled in the same host cell. This method is particularly useful where the bispecific molecule is a mAb x mAb, mAb x Fab, Fab x $F(ab')_2$ or ligand x Fab fusion protein. A bispecific molecule of the invention can be a single chain molecule comprising one single chain antibody and a binding determinant, or a single chain bispecific molecule comprising two binding determinants. Bispecific molecules may comprise at least two single chain molecules. Methods for preparing bispecific molecules are described for example in U.S. Patent Number 5,260,203; U.S. Patent Number 5,455,030; U.S. Patent Number 4,881,175; U.S. Patent Number 5,132,405; U.S. Patent Number 5,091,513; U.S. Patent Number 5,476,786; U.S. Patent Number 5,013,653; U.S. Patent Number 5,258,498; and U.S. Patent Number 5,482,858.

Binding of the bispecific molecules to their specific targets can be confirmed by, for example, enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (REA), FACS analysis, bioassay (e.g., growth inhibition), or Western Blot assay. Each of these assays

generally detects the presence of protein-antibody complexes of particular interest by employing a labeled reagent (e.g., an antibody) specific for the complex of interest. For example, the FcR-antibody complexes can be detected using e.g., an enzyme-linked antibody or antibody fragment which recognizes and specifically binds to the antibody-FcR complexes. Alternatively, the complexes can be detected using any of a variety of other immunoassays. For example, the antibody can be radioactively 4 labeled and used in a radioimmunoassay (RIA) (see, for example, Weintraub; B., Principles of Radioimmunoassays, Seventh Training Course on Radioligand Assay Techniques, The Endocrine Society, March, 1986, which is incorporated by reference herein). The radioactive isotope can be detected by such means as the use of a γ counter or a scintillation counter or by autoradiography.

Pharmaceutical compositions

In another aspect, the present invention provides a composition, e.g., a pharmaceutical composition, containing one or a combination of monoclonal antibodies, or antigen-binding portion(s) thereof, of the present invention, formulated together with a pharmaceutically acceptable carrier. Such compositions may include one or a combination of (e.g., two or more different) antibodies, or immunoconjugates or bispecific molecules of the invention. For example, a pharmaceutical composition of the invention can comprise a combination of antibodies (or immunoconjugates or bispecifics) that bind to different epitopes on the target antigen or that have complementary activities.

Pharmaceutical compositions of the invention also can be administered in combination therapy, i.e., combined with other agents. For example, the combination therapy can include an anti-IL-13 antibody of the present invention combined with at least one other anti-inflammatory agent. Examples of therapeutic agents that can be used in combination therapy are described in greater detail below in the section on uses of the antibodies of the invention.

As used herein, "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents, and the like that are physiologically compatible. The carrier should be suitable for intravenous, intramuscular, subcutaneous, parenteral, spinal or epidermal administration (e.g., by injection or infusion). Depending on the route of administration, the active compound, i.e., antibody, immunoconjuage, or bispecific molecule, may be coated in a

material to protect the compound from the action of acids and other natural conditions that may inactivate the compound.

The pharmaceutical compounds of the invention may include one or more pharmaceutically acceptable salts. A "pharmaceutically acceptable salt" refers to a salt that retains the desired biological activity of the parent compound and does not impart any undesired toxicological effects (see e.g., Berge, S.M., et al., 1977 J. Pharm. Sci. 66:1-19). Examples of such salts include acid addition salts and base addition salts. Acid addition salts include those derived from nontoxic inorganic acids, such as hydrochloric, nitric, phosphoric, sulfuric, hydrobromic, hydroiodic, phosphorous and the like, as well as from nontoxic organic acids such as aliphatic mono- and di-carboxylic acids, phenyl-substituted alkanoic acids, hydroxy alkanoic acids, aromatic acids, aliphatic and aromatic sulfonic acids and the like. Base addition salts include those derived from alkaline earth metals, such as sodium, potassium, magnesium, calcium and the like, as well as from nontoxic organic amines, such as N,N'-dibenzylethylenediamine, N-methylglucamine, chloroprocaine, choline, diethanolamine, ethylenediamine, procaine and the like.

A pharmaceutical composition of the invention also may include a pharmaceutically acceptable anti-oxidant. Examples of pharmaceutically acceptable antioxidants include: water soluble antioxidants, such as ascorbic acid, cysteine hydrochloride, sodium bisulfate, sodium metabisulfite, sodium sulfite and the like; oil-soluble antioxidants, such as ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), lecithin, propyl gallate, alpha-tocopherol, and the like; and metal chelating agents, such as citric acid, ethylenediamine tetraacetic acid (EDTA), sorbitol, tartaric acid, phosphoric acid, and the like.

Examples of suitable aqueous and nonaqueous carriers that may be employed in the pharmaceutical compositions of the invention include water, ethanol, polyols (such as glycerol, propylene glycol, polyethylene glycol, and the like), and suitable mixtures thereof, vegetable oils, such as olive oil, and injectable organic esters, such as ethyl oleate. Proper fluidity can be maintained, for example, by the use of coating materials, such as lecithin, by the maintenance of the required particle size in the case of dispersions, and by the use of surfactants.

These compositions may also contain adjuvants such as preservatives, wetting agents, emulsifying agents and dispersing agents. Prevention of presence of microorganisms may be ensured both by sterilization procedures, supra, and by the inclusion of various antibacterial and antifungal agents, for example, paraben, chlorobutanol, phenol sorbic acid, and the like. It may also be desirable to include isotonic agents, such as sugars, sodium chloride, and the

like into the compositions. In addition, prolonged absorption of the injectable pharmaceutical form may be brought about by the inclusion of agents which delay absorption such as, aluminum monostearate and gelatin.

Pharmaceutically acceptable carriers include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. The use of such media and agents for pharmaceutically active substances is known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the pharmaceutical compositions of the invention is contemplated. Supplementary active compounds can also be incorporated into the compositions.

Therapeutic compositions typically must be sterile and stable under the conditions of manufacture and storage. The composition can be formulated as a solution, microemulsion, liposome, or other ordered structure suitable to high drug concentration. The carrier can be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. In many cases, one can include isotonic agents, for example, sugars, polyalcohols such as mannitol, sorbitol, or sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent that delays absorption for example, monostearate salts and gelatin.

Sterile injectable solutions can be prepared by incorporating the active compound in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by sterilization microfiltration. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the methods of preparation are vacuum drying and freeze-drying (lyophilization) that yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will vary depending upon the subject being treated, and the particular mode of administration. The amount of active ingredient which can be combined with a carrier material to produce a single dosage form will generally be that amount of the

composition which produces a therapeutic effect. Generally, out of one hundred percent, this amount will range from about 0.01 per cent to about ninety-nine percent of active ingredient, from about 0.1 per cent to about 70 per cent, or from about 1 percent to about 30 percent of active ingredient in combination with a pharmaceutically acceptable carrier.

Dosage regimens are adjusted to provide the optimum desired response (e.g., a therapeutic response). For example, a single bolus may be administered, several divided doses may be administered over time or the dose may be proportionally reduced or increased as indicated by the exigencies of the therapeutic situation. It is especially advantageous to formulate parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers to physically discrete units suited as unitary dosages for the subjects to be treated; each unit contains a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the invention are dictated by and directly dependent on the unique characteristics of the active compound and the particular therapeutic effect to be achieved, and the limitations inherent in the art of compounding such an active compound for the treatment of sensitivity in individuals.

For administration of the antibody, the dosage ranges from about 0.0001 to 100 mg/kg, and more usually 0.01 to 5 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 within the range of 1-10 mg/kg. An exemplary treatment regime entails administration once per week, once every two weeks, once every three weeks, once every four weeks, once a month, once every 3 months or once every three to 6 months. Dosage regimens for an anti-IL-13 antibody of the invention may include 1 mg/kg body weight or 3 mg/kg body weight by intravenous or subcutaneous administration, with the antibody being given using one of the following dosing schedules: e.g. every four weeks for six dosages, then every three months; every three weeks; 3 mg/kg body weight once followed by 1 mg/kg body weight every three weeks.

In some methods, two or more monoclonal antibodies with different binding specificities are administered simultaneously, in which case the dosage of each antibody administered falls within the ranges indicated. Antibody is usually administered on multiple occasions. Intervals between single dosages can be, for example, weekly, monthly, every three months or yearly. Intervals can also be irregular as indicated by measuring blood levels of antibody to the target antigen in the patient. In some methods, dosage is adjusted to

achieve a plasma antibody concentration of about 1-1000 μg/ml and in some methods about 25-300 μg/ml.

Alternatively, antibody can be administered as a sustained release formulation, in which case less frequent administration is required. Dosage and frequency vary depending on the half-life of the antibody in the patient. In general, human antibodies show the longest half-life, followed by humanized antibodies, chimeric antibodies, and nonhuman antibodies. The dosage and frequency of administration can vary depending on whether the treatment is prophylactic or therapeutic. In prophylactic applications, a relatively low dosage is administered at relatively infrequent intervals over a long period of time. Some patients continue to receive treatment for the rest of their lives. In therapeutic applications, a relatively high dosage at relatively short intervals is sometimes required until progression of the disease is reduced or terminated or until the patient shows partial or complete amelioration of symptoms of disease. Thereafter, the patient can be administered a prophylactic regime.

Actual dosage levels of the active ingredients in the pharmaceutical compositions of the present invention may be varied so as to obtain an amount of the active ingredient which is effective to achieve the desired therapeutic response for a particular patient, composition, and mode of administration, without being toxic to the patient. The selected dosage level will depend upon a variety of pharmacokinetic factors including the activity of the particular compositions of the present invention employed, or the ester, salt or amide thereof, the route of administration, the time of administration, the rate of excretion of the particular compound being employed, the duration of the treatment, other drugs, compounds and/or materials used in combination with the particular compositions employed, the age, sex, weight, condition, general health and prior medical history of the patient being treated, and like factors well known in the medical arts.

A "therapeutically effective dosage" of an anti-IL-13 antibody of the invention can results in a decrease in severity of disease symptoms, an increase in frequency and duration of disease symptom-free periods, or a prevention of impairment or disability due to the disease affliction.

A composition of the present invention can be administered by one or more routes of administration using one or more of a variety of methods known in the art. As will be appreciated by the skilled artisan, the route and/or mode of administration will vary depending upon the desired results. Routes of administration for antibodies of the invention include intravenous, intramuscular, intradermal, intraperitoneal, subcutaneous, spinal or other parenteral routes of administration, for example by injection or infusion. The phrase

"parenteral administration" as used herein means modes of administration other than enteral and topical administration, usually by injection, and includes, without limitation, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intraorbital, intracardiac, intradermal, intraperitoneal, transtracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal, epidural and intrastemal injection and infusion.

Alternatively, an antibody of the invention can be administered by a nonparenteral route, such as a topical, epidermal or mucosal route of administration, for example, intranasally, orally, vaginally, rectally, sublingually or topically.

The active compounds can be prepared with carriers that will protect the compound against rapid release, such as a controlled release formulation, including implants, transdermal patches, and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Many methods for the preparation of such formulations are patented or generally known to those skilled in the art. See, e.g., Sustained and Controlled Release Drug Delivery Systems, J.R. Robinson, ed., Marcel Dekker, Inc., New York, 1978.

Therapeutic compositions can be administered with medical devices known in the art. For example, in one embodiment, a therapeutic composition of the invention can be administered with a needleless hypodermic injection device, such as the devices shown in U.S. Patent Nos. 5,399,163; 5,383,851; 5,312,335; 5,064,413; 4,941,880; 4,790,824 or 4,596,556. Examples of well known implants and modules useful in the present invention include: U.S. Patent No. 4,487,603, which shows an implantable micro-infusion pump for dispensing medication at a controlled rate; U.S. Patent No. 4,486,194, which shows a therapeutic device for administering medicants through the skin; U.S. Patent No. 4,447,233, which shows a medication infusion pump for delivering medication at a precise infusion rate; U.S. Patent No. 4,447,224, which shows a variable flow implantable infusion apparatus for continuous drug delivery; U.S. Patent No. 4,439,196, which shows an osmotic drug delivery system having multi-chamber compartments; and U.S. Patent No. 4,475,196, which shows an osmotic drug delivery system. These patents are incorporated herein by reference. Many other such implants, delivery systems, and modules are known to those skilled in the art.

In certain embodiments, the human monoclonal antibodies of the invention can be formulated to ensure proper distribution in vivo. For example, the blood-brain barrier (BBB) excludes many highly hydrophilic compounds. To ensure that the therapeutic compounds of the invention cross the BBB (if desired), they can be formulated, for example, in liposomes.

For methods of manufacturing liposomes, see, e.g., U.S. Patents 4,522,811; 5,374,548; and 5,399,331. The liposomes may comprise one or more moieties which are selectively transported into specific cells or organs, thus enhance targeted drug delivery (see, e.g., V.V. Ranade, 1989 J. Cline Pharmacol. 29:685). Exemplary targeting moieties include folate or biotin (see, e.g., U.S. Patent 5,416,016 to Low et al.); mannosides (Umezawa et al., 1988 Biochem. Biophys. Res. Commun. 153:1038); antibodies (P.G. Bloeman et al., 1995 FEBS Lett. 357:140; M. Owais et al., 1995 Antimicrob. Agents Chernother. 39:180); surfactant protein A receptor (Briscoe et al., 1995 Am. J. Physiol.1233:134); p120 (Schreier et al., 1994 J. Biol. Chem. 269:9090); see also K. Keinanen; M.L. Laukkanen, 1994 FEBSLett. 346:123; J.J. Killion; I.J. Fidler, 1994 Imrnunomethods 4:273.

Uses and methods of the invention

The antibodies (and immunoconjugates and bispecific molecules) of the present invention have in vitro and in vivo diagnostic and therapeutic utilities. For example, these molecules can be administered to cells in culture, e.g. in vitro or in vivo, or in a subject, e.g., in vivo, to treat, prevent or diagnose a variety of disorders. The term "subject" as used herein in intended to include human and non-human animals. Non-human animals includes all vertebrates, e.g., mammals and non-mammals, such as non-human primates, sheep, dogs, cats, cows, horses, chickens, amphibians, and reptiles. The methods are particularly suitable for treating human patients having a disorder associated with aberrant IL-13 expression. When antibodies to IL-13 are administered together with another agent, the two can be administered in either order or simultaneously.

In one embodiment, the antibodies (and immunoconjugates and bispecific molecules) of the invention can be used to detect levels of IL-13, or levels of cells that contain IL-13. This can be achieved, for example, by contacting a sample (such as an in vitro sample) and a control sample with the anti-IL-13 antibody under conditions that allow for the formation of a complex between the antibody and IL-13. Any complexes formed between the antibody and IL-13 are detected and compared in the sample and the control. For example, standard detection methods, well known in the art, such as ELISA and flow cytometic assays, can be performed using the compositions of the invention.

Accordingly, in one aspect, the invention further provides methods for detecting the presence of IL-13 (e.g., human IL-13 antigen) in a sample, or measuring the amount of IL-13, comprising contacting the sample, and a control sample, with an antibody of the invention, or an antigen binding portion thereof, which specifically binds to IL-13, under conditions that

allow for formation of a complex between the antibody or portion thereof and IL-13. The formation of a complex is then detected, wherein a difference in complex formation between the sample compared to the control sample is indicative of the presence of IL-13 in the sample.

Also within the scope of the invention are kits consisting of the compositions (e.g., antibodies, human antibodies, immunoconjugates and bispecific molecules) of the invention and instructions for use. The kit can further contain a least one additional reagent, or one or more additional antibodies of the invention (e.g., an antibody having a complementary activity which binds to an epitope on the target antigen distinct from the first antibody). Kits typically 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 with the kit, or which otherwise accompanies the kit.

The invention having been fully described, it is further illustrated by the following examples and claims, which are illustrative and are not meant to be further limiting. Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation, numerous equivalents to the specific procedures described herein. Such equivalents are within the scope of the present invention and claims. The contents of all references, including issued patents and published patent applications, cited throughout this application are hereby incorporated by reference.

Examples

Example 1: Generation of human IL-13-specific antibodies from immunized splenic libraries

The RNA from spleen was used to generate a phage display library of randomly assorted H and L chain variable domains in a Fab phage display vector as described in US Patent 6,794,132. The phage display library was subjected to five rounds of selection using biotinylated hrIL-13 in a solution-phase equilibrium binding protocol as described in the patent. The first four rounds of selection employed hrIL-13 at 10^{-8} M and the last round of selection employed hrIL-13 at 10^{-9} M. The final signal to noise ratio determined by counting pfu's recovered in the presence of antigen divided by pfu's recovered in the absence of antigen was 37 for this library, indicating that greater than 90% of the phage selected were expressing antibodies that bound hrIL-13. The phage display library was then subcloned into a plasmid vector for the expression of soluble Fab as described in US Patent 6,794,132. The subcloned is library comprises plasmid vectors in *E. coli*, each plasmid encoding a

monoclonal Fab fragment. The subclone library was plated out and colonies representing individual clones were picked to inoculate 96-well plates. After overnight growth, the plate cultures were used to archive frozen cell banks for the clones in 96-well plates and also to seed replica 96-well plates which were induced to express monoclonal antibodies. The next day, these 96-well plate cultures were subjected to detergent extraction and purification to recover microgram quantities of antibodies. The purified antibodies were treated to remove endotoxin and sterile filtered terminally. ELISA assays were conducted using biotinylated rhIL-13 coated on avidin plates to identify which wells contained functional positives. Sandwich assays targeting the constant region of the antibodies were used to determine antibody concentrations in different wells. The 96-well plates containing the antibodies and the assay data were assessed for biological activity. The clones of interest in the 96-well frozen cell banks were then sequenced to identify the ones expressing unique antibodies. Subsequently, the frozen cell banks of these unique clones were used to seed small scale shake flask cultures and grown overnight. Large scale flasks were seeded using the overnight cultures and then induced to express antibodies. The next day, the flask cultures were mechanically homogenized and purified to yield milligram quantities of antibodies. The purified Fabs were processed for endotoxin removal and subjected to terminal sterile filtration. The functional activity of these antibodies was demonstrated by ELISA using biotinylated rhIL-13 coated on avidin plates. The antibody concentrations were determined by absorbance measurement at 280 nm. The purified Fabs were assessed for in vitro binding and activity in a cell based assay.

Example 2: Quantitative analysis of binding affinities: determination of anti-human IL-13 Fab candidates

Surface plasmon resonance measurements quantifying the interaction of anti-IL-13 Fabs with several hrIL-13 are performed using the optical biosensor, BIAcore 2000. Specific binding of IL-13 to a respective IL-13 Fab immobilized on a BIAcore chip can be measured by following accumulation of the ligand on the receptor. The microscopic association (k_{on}) and dissociation rates (k_{off}) can be obtained directly from the mass accumulation rates on the chip and are expressed in response units (RUs). Anti-IL-13 Fab is immobilized on the chip surface via a secondary anti-human Lκ antibody (Jackson Immunochemicals). This capture antibody was covalently bound using the 'Amine coupling kit' (BIAcore, Cat.No. BR-1000-50) as recommended in the manufacturers' protocols. 250 µl of varying concentrations of

hrIL-13 was injected at flow rate of 20 µl /min and the kinetic trace was recorded. The chip surface was regenerated by two acid wash steps using 100 mM HCl and injecting 10 µl with a flow rate of 20 µl/min. This treatment leads to dissociation of the Fab IL-13 complex due to reversible acid denaturation. No significant loss of binding activity was observed when the antibody was reinjected for a subsequent run. The kinetic traces were evaluated with the BIAcore software applying the 1:1 Langmuir association model

The summarized affinity data on human IL-13 is shown in Table 1 herein.

Table 1

Fab	KD [pM] human IL-13
01471/G6	100 ± 2
03161/H2	197 ± 12
01951/G12	480 ± 68
01771/E10	343 ± 54

Example 3: Conversion into the IgG format

Antibody DNA sequencing templates were purified from 3 ml cultures using QIAprep minipreps (Qiagen Inc.). Templates were sequenced using an Applied Biosystems 3100 Avant Genetic Analyzer according to manufacturer's specifications. The heavy and kappa chain variable regions of selected clones were separately amplified from the sequencing templates by PCR, purified by agarose gel electrophoresis, and excised and purified from the gel. Plasmids encoding the V_H and V_L were cloned into expression cassettes for human kappa light and human IgG_1 heavy chains. The Sp2/0 parental cell line was transfected with two vectors, one for the light and one for heavy chain vectors. Transfected cells were selected and amplified using G418 and methotrexate respectively resulting in the emergence of resistant, amplified cell pools producing the antibodies with titers ranging from 5mg/L to 30mg/L. Dilution cloning was then employed, resulting in the isolation of 127 viable clones from six 96-well plates. Emerging cell lines were then tested for productivity in a fed-batch shaker format. Stability testing to confirm the stable integration of the expression constructs and robust expression of product were also performed over a 90-day period. Northern blots exhibited single, full length RNAs with equal band intensities, indicating similar expression levels for both the heavy chain and light chain.

Example 4: In vitro characterization of anti-IL-13 full antibodies in a cell based assay

IL-13 is a potent inducer of eotaxin release from human lung fibroblasts. The ability of the antibodies to neutralize the bioactivity of IL-13 was assessed in an IL-13-induced eotaxin release assay using human lung fibroblasts. Briefly, cells (2 x 10^4 cells per well in a volume of 100µl) were plated out in each well of a 96 well tissue culture plate. The cells were stimulated with a concentration of IL-13 conferring 80% of the maximal eotaxin release, which was pre-determined for each batch of cells using a standard curve of 0-100ng/ml IL-13. Varying concentrations of the antibodies were co-applied to the cells. The cells were allowed to incubate for 24h at 37°C, 5% CO_2 and the culture media was harvested and stored at -20°C until required. Eotaxin levels within the media were measured by specific ELISA (R&D systems) where the sensitivity of assay was between 15-1000 pg/ml.

The anti-IL-13 Fabs were thereby analyzed with respect to EC_{50} as described above and shown in Table 2.

Table 2

Antibody	EC_{50} [nM] human IL-13
01471/G6	1.23 ± 0.4
03161/H2	0.95 ± 0.2
01951/G12	0.33 ± 0.1
01771/E10	1.71 ± 0.5

Example 5: Sequence analysis of the anti-IL-13 antibodies

The nucleotide sequences of the heavy and light chain variable regions (V_H and V_L) of all antibodies were determined. Amino acid sequences of the complementarity determining regions (CDRs) are listed in Table 3 and 4 herein. The CDRs according Kabat definition (E. Kabat et al, 1991, Sequences of Proteins of Immunological Interest, 5th edition, Public Health Service, National Institute of Health, Bethesda, MD, are listed in Table 3a and 4a.

Table 3

Antibody	HCDR1	SEQ ID No. HCDR1	HCDR2	SEQ ID No. HCDR2	HCDR3	SEQ ID No. HCDR3
01471/G6	GFTFSNYG	1	IWYDGSN	3	VKGSGDIP	4
03161/H2	GFTFSNYG	1	IWYDGSN	3	VKGSGDIP	4
01951/G12	GFTFSSYG	2	IWYDGSN	3	ARLWFGDLD	5
01771/E10	GFTFSSYG	2	IWYDGSN	3	ARLWFGDLD	5

Table 3a

Antibody	HCDR1	SEQ ID No. HCDR1	HCDR2	SEQ ID No. HCDR2	HCDR3	SEQ ID No. HCDR3
01471/G6	NYGMH	6	IIWYDGSNKYYADSVKG	8	GSGDIPFDY	9
03161/H2	NYGMH	6	IIWYDGSNKYYADSVKG	8	GSGDIPFDY	9
01951/G12	SYGMH	7	IIWYDGSNKYYADSVKG	8	LWFGDLDAFDI	10
01771/E10	SYGMH	7	IIWYDGSNKYYADSVKG	8	LWFGDLDAFDI	10

Table 4

Antibody	LCDR1	SEQ ID No. LCDR1	LCDR2	SEQ ID No. LCDR2	LCDR3	SEQ ID No. LCDR3
01471/G6	QSVSSY	11	DA	12	HQRSHWPPI	13
03161/H2	QSVSSY	11	DA	12	HQRSHWPPI	13
01951/G12	QSVSSY	11	DA	12	QQRSSWPPV	14
01771/E10	QSVSSY	11	DA	12	HQRSSWPPI	15

Table 4a

Antibody	LCDR1	SEQ ID No. LCDR1	LCDR2	SEQ ID No. LCDR2	LCDR3	SEQ ID No. LCDR3
01471/G6	RASQSVSSYLA	16	DASNRAT	19	HQRSHWPPIFT	20
03161/H2	RASQSVSSYLA	16	DASNRAT	19	HQRSHWPPIFT	20
01951/G12	RAGQSVSSYLV	17	DASNRAT	19	QQRSSWPPVYT	21
01771/E10	RASQSVSSYLA	18	DASNRAT	19	HQRSSWPPIFT	22

The sequences of the antibodies of the previous tables, including framework regions, are shown below. The full IgG1 antibody light and heavy chain constant regions are also shown below, incorporating, as an example, the variable regions of antibody 01951/G12 (emboldened).

01471/G6 Antibody Sequence

(i) HC variable region

The HC variable amino acid sequence for 01471/G6 is shown in SEQ ID NO: 23 and is encoded by the nucleotide sequence shown in SEQ ID NO: 24

```
E  V  Q  L  V  E  S  G  G  G  V  V  Q  P  G  R  S  L  R  L
gaagtgcagctggtggagtctgggggaggcgtggtccagcctgggaggtccctgagactc  60

S  C  A  A  S  G  F  T  F  S  N  Y  G  M  H  W  V  R  Q  A
tcctgtgcagcgtctggattcaccttcagtaactatggcatgcactgggtccgccaggct  120

P  G  K  G  L  E  W  V  A  I  I  W  Y  D  G  S  N  K  Y  Y
ccaggcaaggggctggagtgggtggcaattatatggtatgatggaagtaataaatactat  180

A  D  S  V  K  G  R  F  T  I  S  R  D  N  S  K  N  T  L  Y
gcagactccgtgaagggccgattcaccatctccagagacaattccaagaacacgctgtat  240

L  Q  M  N  S  L  R  A  E  D  T  A  V  Y  Y  C  V  K  G  S
ctgcaaatgaacagtctgagagccgaggacacggctgtgtattactgtgtgaaaggatct  300

G  D  I  P  F  D  Y  W  G  Q  G  T  L  V  T  (SEQ ID NO : 23)
ggggatattccctttgactactggggccagggaaccctggtcacc  345 (SEQ ID NO :24)
```

(ii) LC variable region

The LC variable amino acid sequence for 01471/G6 is shown in SEQ ID NO: 25 and is encoded by the nucleotide sequence shown in SEQ ID NO: 26

```
E  I  V  L  T  Q  S  P  A  T  L  S  S  S  P  G  E  R  A  T
gaaattgtgttgacgcagtctccagccaccctgtcttcgtctccaggggaaagagccacc    60

L  S  C  R  A  S  Q  S  V  S  S  Y  L  A  W  Y  Q  Q  K  P
ctctcctgcagggccagtcagagtgttagcagctacttagcctggtaccaacagaaacct   120

G  Q  A  P  R  L  L  I  Y  D  A  S  N  R  A  T  G  I  P  A
ggccaggctcccaggctcctcatctatgatgcatccaacagggccactggcatcccagcc   180

R  F  S  G  S  G  S  G  T  D  F  T  L  T  I  S  S  L  E  P
aggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagcctagagcct   240

E  D  F  A  V  Y  Y  C  H  Q  R  S  H  W  P  P  I  F  T  F
gaagattttgcagtctattactgtcatcagcgtagccactggcctcccatattcactttc   300

G  P  G  T  (SEQ ID NO: 25)
ggccctgggacc   312 (SEQ ID NO: 26)
```

03161/H2 Antibody

(i) HC variable region

The HC variable amino acid sequence for 03161/H2 is shown in SEQ ID NO: 27 and is encoded by the nucleotide sequence shown in SEQ ID NO: SEQ ID No. 28

```
E  V  Q  L  V  E  S  G  G  G  V  V  Q  P  G  R  S  L  R  L
gaagtgcagctggtggagtctgggggaggcgtggtccagcctgggaggtccctgagactc    60

S  C  A  A  S  G  F  T  F  S  N  Y  G  M  H  W  V  R  Q  A
tcctgtgcagcgtctggattcaccttcagtaactatggcatgcactgggtccgccaggct   120

P  G  K  G  L  E  W  V  A  I  I  W  Y  D  G  S  N  K  Y  Y
ccaggcaaggggctggagtgggtggcaattatatggtatgatggaagtaataaatactat   180

A  D  S  V  K  G  R  F  T  I  S  R  D  N  S  K  N  T  L  Y
gcagactccgtgaagggccgattcaccatctccagagacaattccaagaacacgctgtat   240

L  Q  M  N  S  L  R  A  E  D  T  A  V  Y  Y  C  V  K  G  S
ctgcaaatgaacagtctgagagccgaggacacggctgtgtattactgtgtgaaaggatct   300

G  D  I  P  F  D  Y  W  G  Q  G  T  L  V  T (SEQ ID NO : 27)
ggggatattccctttgactactggggccagggaaccctggtcacc   345> (SEQ ID NO : 28)
```

(ii) LC variable region

The LC variable amino acid sequence for 03161/H2 is shown in SEQ ID NO: 29 and is encoded by the nucleotide sequence shown in SEQ ID NO: 30

```
E  I  V  L  T  Q  S  P  A  T  L  S  S  S  P  G  E  R  A  T
gaaattgtgttgacgcagtccccagccaccctgtcttcgtctccaggggaaagagccacc    60

L  S  C  R  A  S  Q  S  V  S  S  Y  L  A  W  Y  Q  Q  K  P
ctctcctgcagggccagtcagagtgttagcagctacttagcctggtaccaacagaaacct   120

G  Q  A  P  R  L  L  I  Y  D  A  S  N  R  A  T  G  T  P  A
ggccaggctcccaggctcctcatctatgatgcatccaacagggccactggcaccccagcc   180

R  F  S  G  S  G  S  G  T  D  F  T  L  T  I  S  S  L  E  P
aggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagcctagagcct   240

E  D  F  A  V  Y  Y  C  H  Q  R  S  H  W  P  P  I  F  T  F
gaagattttgcagtctattactgtcatcagcgtagccactggcctcccatattcactttc   300

G  P  G  T  (SEQ ID NO :29)
ggccctgggacc   312 (SEQ ID NO :30)
```

01951/G12 Antibody sequence

(i) HC variable region

The HC variable amino acid sequence for 01951/G12 is shown in SEQ ID NO: 31 and is encoded by the nucleotide sequence shown in SEQ ID NO: 32

```
E  V  Q  L  V  E  S  G  G  G  V  V  Q  P  G  R  S  L  R  L
gaagtgcagctggtggagtctgggggaggcgtggtccagcctgggaggtccctgagactc    60

S  C  A  A  S  G  F  T  F  S  S  Y  G  M  H  W  V  R  Q  A
tcctgtgcagcgtctggattcaccttcagtagctatggcatgcactgggtccgccaggct   120

P  G  K  G  L  E  W  V  A  I  I  W  Y  D  G  S  N  K  Y  Y
ccaggcaaggggctggagtgggtggcaattatatggtatgatggaagtaataaatactat   180

A  D  S  V  K  G  R  F  T  I  S  R  D  N  S  K  N  T  L  Y
gcggactccgtgaagggccgattcaccatctccagagacaattccaagaacacgctgtat   240

L  Q  M  N  S  L  R  A  E  D  T  A  V  Y  Y  C  A  R  L  W
ctgcaaatgaacagcctgagagccgaggacacggctgtgtattactgtgcgaggctatgg   300

F  G  D  L  D  A  F  D  I  W  G  Q  G  T  M  V  T (SEQ ID NO :31)
ttcggggacttagatgcttttgatatctggggccaagggacaatggtcacc      351 (SEQ ID
NO :32)
```

(ii) LC variable region

The LC variable amino acid sequence for 01951/G12 is shown in SEQ ID NO: 33 and is encoded by the nucleotide sequence shown in SEQ ID NO: 34

```
E  I  V  L  T  Q  S  P  A  T  L  S  L  S  P  G  E  R  A  I
gaaattgtgttgacgcagtctccagccaccctgtctttgtctccaggggaaagagccatc  60

L  S  C  R  A  G  Q  S  V  S  S  Y  L  V  W  Y  Q  Q  K  P
ctctcctgcagggccggtcagagtgttagcagttacttagtctggtaccaacagaaacct  120

G  Q  A  P  R  L  L  I  Y  D  A  S  N  R  A  T  G  I  P  A
ggccaggctcccaggctcctcatctatgatgcatccaacagggccactggcatcccagcc  180

R  F  S  G  S  G  S  G  T  D  F  T  L  T  I  S  S  L  E  P
aggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagcctagagcct  240

E  D  F  A  V  Y  Y  C  Q  Q  R  S  S  W  P  P  V  Y  T  F
gaagattttgcagtttattactgtcagcagcgcagcagctggcctccggtgtacactttt  300

G  Q  G  T (SEQ ID NO :33)
ggccaggggacc  312 (SEQ ID NO :34)
```

01771/E10 Antibody Sequence

(i) HC variable region

The HC variable amino acid sequence for 01771/E10 is shown in SEQ ID NO: 35 and is encoded by the nucleotide sequence shown in SEQ ID NO: 36

```
Q V Q L V Q S G G G V V Q P G R S L R L
caggtgcagctggtgcagtctgggggaggcgtggtccagcctgggaggtccctgagactc   60

S C A A S G F T F S S Y G M H W V R Q A
tcctgtgcggcgtctggattcaccttcagtagctatggcatgcactgggtccgccaggct   120

P G K G L E W V A I I W Y D G S N K Y Y
ccaggcaaggggctggagtgggtggcaattatatggtatgatggaagtaataaatactat   180

A D S V K G R F T I S R D N S K N T L Y
gcggactccgtgaagggccgattcaccatctccagagacaattccaagaacacgctatat   240

L Q M N S L R A E D T A V Y Y C A R L W
ctacaaatgaacagcctgagagccgaggacacggctgtgtattactgtgcgaggctatgg   300

F G D L D A F D I W G Q G T M V T (SEQ ID NO :35)
ttcggggacttagatgcttttgatatctggggccaagggacaatggtcacc   351 (SEQ ID NO :36)
```

(ii) LC variable region

The LC variable amino acid sequence for 01771/E10 is shown in SEQ ID NO: 37 and is encoded by the nucleotide sequence shown in SEQ ID NO: 38

```
E I V L T Q S P A T L S L S P G E R A T
gaaattgtgttgacgcagtctccagccaccctgtctttgtctccaggggaaagagccacc   60

L S C R A S Q S V S S Y L A W Y Q Q K P
ctctcctgcagggccagtcagagtgttagcagctacttagcctggtaccaacagaaacct   120

G Q A P R L L I Y D A S N R A T G I P A
ggccaggctcccaggctcctcatctatgatgcatccaacagggccactggcatcccagcc   180

R F S G S G S G T D F T L T I S S L E P
aggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagcctagagcct   240

E D F A V Y Y C H Q R S S W P P I F T F
gaagattttgcggtttattactgtcatcagcgtagcagctggcccccgatattcactttc   300

G P G T (SEQ ID NO :37)
ggccctgggacc   312 (SEQ ID NO :38)
```

Full Antibody IgG1 Light Chain Sequence Incorporating The Variable Region Of Antibody 01951/G12 (Emboldened)

The LC amino acid sequence is shown in SEQ ID NO: 39 and is encoded by the nucleotide sequence of SEQ ID NO: 40

```
        M  S  V  L  T  Q  V  L  A  L  L  L  L  W  L  T  G
    1   ATGAGTGTGC TCACTCAGGT CCTGGCGTTG CTGCTGCTGT GGCTTACAGG

        T  R  C  E  I  V  L  T  Q  S  P  A  T  L  S  L  S
   51   TACGCGTTGT GAAATTGTGT TGACGCAGTC TCCAGCCACC CTGTCTTTGT

        P  G  E  R  A  I  L  S  C  R  A  G  Q  S  V  S
  101   CTCCAGGGGA AAGAGCCATC CTCTCCTGCA GGGCCGGTCA GAGTGTTAGC

        S  Y  L  V  W  Y  Q  Q  K  P  G  Q  A  P  R  L  L
  151   AGTTACTTAG TCTGGTACCA ACAGAAACCT GGCCAGGCTC CCAGGCTCCT

        I  Y  D  A  S  N  R  A  T  G  I  P  A  R  F  S  G
  201   CATCTATGAT GCATCCAACA GGGCCACTGG CATCCCAGCC AGGTTCAGTG

        S  G  S  G  T  D  F  T  L  T  I  S  S  L  E  P
  251   GCAGTGGGTC TGGGACAGAC TTCACTCTCA CCATCAGCAG CCTAGAGCCT

        E  D  F  A  V  Y  Y  C  Q  Q  R  S  S  W  P  P  V
  301   GAAGATTTTG CAGTTTATTA CTGTCAGCAG CGCAGCAGCT GGCCTCCGGT

        Y  T  F  G  Q  G  T  K  L  E  I  K  R  T  V  A  A
  351   GTACACTTTT GGCCAGGGGA CCAAGCTTGA AATCAAACGA ACTGTGGCTG

        P  S  V  F  I  F  P  P  S  D  E  Q  L  K  S  G
  401   CACCATCTGT CTTCATCTTC CCGCCATCTG ATGAGCAGTT GAAATCTGGA

        T  A  S  V  V  C  L  L  N  N  F  Y  P  R  E  A  K
  451   ACTGCCTCTG TTGTGTGCCT GCTGAATAAC TTCTATCCCA GAGAGGCCAA

        V  Q  W  K  V  D  N  A  L  Q  S  G  N  S  Q  E  S
  501   AGTACAGTGG AAGGTGGATA ACGCCCTCCA ATCGGGTAAC TCCCAGGAGA

        V  T  E  Q  D  S  K  D  S  T  Y  S  L  S  S  T
  551   GTGTCACAGA GCAGGACAGC AAGGACAGCA CCTACAGCCT CAGCAGCACC

        L  T  L  S  K  A  D  Y  E  K  H  K  V  Y  A  C  E
  601   CTGACGCTGA GCAAAGCAGA CTACGAGAAA CACAAAGTCT ACGCCTGCGA

        V  T  H  Q  G  L  S  S  P  V  T  K  S  F  N  R  G
  651   AGTCACCCAT CAGGGCCTGA GCTCGCCCGT CACAAAGAGC TTCAACAGGG

        E  C  *  (SEQ ID NO:39)
  701   GAGAGTGTTA G (SEQ ID NO:40)
```

Full Antibody IgG1 Heavy Chain Sequence Incorporating The Variable Region Of Antibody 01951/G12 (Emboldened)

The HC amino acid sequence is shown in SEQ ID NO: 41 and is encoded by the nucleotide sequence of SEQ ID NO: 42

```
        M  A  W  V  W  T  L  P  F  L  M  A  A  A  Q  S  V
   1    ATGGCTTGGG TGTGGACCTT GCCATTCCTG ATGGCAGCTG CCCAAAGTGT

        Q  A  E  V  Q  L  V  E  S  G  G  G  V  V  Q  P  G
  51    CCAGGCAGAA GTGCAGCTGG TGGAGTCTGG GGGAGGCGTG GTCCAGCCTG

        R  S  L  R  L  S  C  A  A  S  G  F  T  F  S  S
 101    GGAGGTCCCT GAGACTCTCC TGTGCAGCGT CTGGATTCAC CTTCAGTAGC

        Y  G  M  H  W  V  R  Q  A  P  G  K  G  L  E  W  V
 151    TATGGCATGC ACTGGGTCCG CCAGGCTCCA GGCAAGGGGC TGGAGTGGGT

        A  I  I  W  Y  D  G  S  N  K  Y  Y  A  D  S  V  K
 201    GGCAATTATA TGGTATGATG GAAGTAATAA ATACTATGCG GACTCCGTGA

        G  R  F  T  I  S  R  D  N  S  K  N  T  L  Y  L
 251    AGGGCCGATT CACCATCTCC AGAGACAATT CCAAGAACAC GCTGTATCTG

        Q  M  N  S  L  R  A  E  D  T  A  V  Y  Y  C  A  R
 301    CAAATGAACA GCCTGAGAGC CGAGGACACG GCTGTGTATT ACTGTGCGAG

        L  W  F  G  D  L  D  A  F  D  I  W  G  Q  G  T  M
 351    GCTATGGTTC GGGGACTTAG ATGCTTTTGA TATCTGGGGC CAAGGGACAA

        V  T  V  S  S  A  S  T  K  G  P  S  V  F  P  L
 401    TGGTCACCGT CTCCTCAGCC TCCACCAAGG GCCCATCGGT CTTCCCCCTG

        A  P  S  S  K  S  T  S  G  G  T  A  A  L  G  C  L
 451    GCACCCTCCT CCAAGAGCAC CTCTGGGGGC ACAGCGGCCC TGGGCTGCCT

        V  K  D  Y  F  P  E  P  V  T  V  S  W  N  S  G  A
 501    GGTCAAGGAC TACTTCCCCG AACCGGTGAC GGTGTCGTGG AACTCAGGCG

        L  T  S  G  V  H  T  F  P  A  V  L  Q  S  S  G
 551    CCCTGACCAG CGGCGTGCAC ACCTTCCCGG CTGTCCTACA GTCCTCAGGA

        L  Y  S  L  S  S  V  V  T  V  P  S  S  S  L  G  T
 601    CTCTACTCCC TCAGCAGCGT CGTGACCGTG CCCTCCAGCA GCTTGGGCAC

        Q  T  Y  I  C  N  V  N  H  K  P  S  N  T  K  V  D
 651    CCAGACCTAC ATCTGCAACG TGAATCACAA GCCCAGCAAC ACCAAGGTGG

        K  R  V  E  P  K  S  C  D  K  T  H  T  C  P  P
 701    ACAAGAGAGT TGAGCCCAAA TCTTGTGACA AAACTCACAC ATGCCCACCG

        C  P  A  P  E  L  L  G  G  P  S  V  F  L  F  P  P
 751    TGCCCAGCAC CTGAACTCCT GGGGGGACCG TCAGTCTTCC TCTTCCCCCC

        K  P  K  D  T  L  M  I  S  R  T  P  E  V  T  C  V
 801    AAAACCCAAG GACACCCTCA TGATCTCCCG GACCCCTGAG GTCACATGCG

        V  V  D  V  S  H  E  D  P  E  V  K  F  N  W  Y
 851    TGGTGGTGGA CGTGAGCCAC GAAGACCCTG AGGTCAAGTT CAACTGGTAC
```

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          V  D  G  V   E  V  H   N  A  K   T  K  P  R   E  E  Q
    901   GTGGACGGCG TGGAGGTGCA TAATGCCAAG ACAAAGCCGC GGGAGGAGCA

           Y  N  S   T  Y  R  V   V  S  V   L  T  V   L  H  Q  D
    951   GTACAACAGC ACGTACCGTG TGGTCAGCGT CCTCACCGTC CTGCACCAGG

            W  L  N   G  K  E   Y  K  C  K   V  S  N   K  A  L
   1001   ACTGGCTGAA TGGCAAGGAG TACAAGTGCA AGGTCTCCAA CAAAGCCCTC

          P  A  P  I   E  K  T   I  S  K   A  K  G  Q   P  R  E
   1051   CCAGCCCCCA TCGAGAAAAC CATCTCCAAA GCCAAAGGGC AGCCCCGAGA

           P  Q  V   Y  T  L  P   P  S  R   E  E  M   T  K  N  Q
   1101   ACCACAGGTG TACACCCTGC CCCCATCCCG GGAGGAGATG ACCAAGAACC

            V  S  L   T  C  L   V  K  G  F   Y  P  S   D  I  A
   1151   AGGTCAGCCT GACCTGCCTG GTCAAAGGCT TCTATCCCAG CGACATCGCC

          V  E  W  E   S  N  G   Q  P  E   N  N  Y  K   T  T  P
   1201   GTGGAGTGGG AGAGCAATGG GCAGCCGGAG AACAACTACA AGACCACGCC

           P  V  L   D  S  D  G   S  F  F   L  Y  S   K  L  T  V
   1251   TCCCGTGCTG GACTCCGACG GCTCCTTCTT CCTCTATAGC AAGCTCACCG

            D  K  S   R  W  Q   Q  G  N  V   F  S  C   S  V  M
   1301   TGGACAAGAG CAGGTGGCAG CAGGGGAACG TCTTCTCATG CTCCGTGATG

          H  E  A  L   H  N  H   Y  T  Q   K  S  L  S   L  S  P
   1351   CATGAGGCTC TGCACAACCA CTACACGCAG AAGAGCCTCT CCCTGTCCCC

           G  K  * (SEQ ID NO:41)
   1401   GGGTAAATGA (SEQ ID NO:42)
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Claims

1. An isolated human or humanized IL 13 antibody comprising an antigen- binding region where the H-CDRI , H-CDR2 and H-CDR3 and L-CDRI , L-CDR2 and L-CDR3 regions depicted in an amino acid sequence together are SEQ ID NO: 7, SEQ ID NO:8, SEQ ID NO: 10, and SEQ ID NO: 17, SEQ ID NO: 19, SEQ ID NO: 21, and conservative variants thereof.

2. An antibody according to claim 1 comprising an HC variable region according to SEQ ID NO: 31 and an LC variable region according to SEQ ID NO: 33, or a sequence having at least 90 percent sequence identity thereof.

3. An antibody according to any one of claims 1-2, which is an IgGl or an IgG4.

4. A pharmaceutical composition comprising an antibody or functional fragment thereof according to any of claims 1-3 and a pharmaceutically acceptable carrier or excipient therefor.