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(54) **INTERLEUKIN-5 SPECIFIC RECOMBINANT ANTIBODIES**

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**Related U.S. Patent Documents**

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530/388.23; 424/133.1; 424/145.1; 435/335;  
435/328; 435/69.6; 435/69.7

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530/388.1, 388.23; 435/69.6, 69.7, 328, 335;  
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See application file for complete search history.

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(57) **ABSTRACT**

An effective anti-IL-5 recombinant antibody molecule comprising heavy and/or light chain antigen-binding residues from a donor antibody.

**7 Claims, 12 Drawing Sheets**

FIG. 1

GAA TCT GGA GGA GGC TTG GTA CAG CCA TCA CAG ACC  
E S G G G L V Q P S Q T

CTG TCT CTC ACC TGC ACT GTC TCT GGG TTA TCA TTA  
L S L T C T V S G L S L

ACC AGC AAT AGT GTG AAC TGG ATT CGG CAG CCT CCA  
T S N S V N W I R Q P P

GGA AAG GGT CTG GAG TGG ATG GGA CTA ATA TGG AGT  
G K G L E W M G L I W S

AAT GGA GAC ACA GAT TAT AAT TCA GCT ATC AAA TCC  
N G D T D Y N S A I K S

CGA CTG AGC ATC AGT AGG GAC ACC TCG AAG AGC CAG  
R L S I S R D T S K S Q

GTT TTC TTA AAG ATG AAC AGT CTG CAA AGT GAA GAC  
V F L K M N S L Q S E D

ACA GCC ATG TAC TTC TGT GCC AGA GAG TAC TAC GGC  
T A M Y F C A R E Y Y G

TAC TTT GAT TAC TGG GGC CAA GGA GTC ATG GTC ACA  
Y F D Y W G Q G V M V T

GTC TCC TCA SEQ ID NO: 5  
V S S SEQ ID NO: 6

FIG.2

ATG	GCT	GTG	CCC	ACT	CAG	CTC	CTG	GGG	TTG	TTG	TTG
M	A	V	P	T	Q	L	L	G	L	L	L
CTG	TGG	ATT	ACA	GAT	GCC	ATA	TGT	GAC	ATC	CAG	ATG
L	W	I	T	D	A	I	C	D	I	Q	M
ACA	CAG	TCT	CCA	GCT	TCC	CTG	TCT	GCA	TCT	CTG	GGA
T	Q	S	P	A	S	L	S	A	S	L	G
GAA	ACT	ATC	TCC	ATC	GAA	TGT	CTA	GCA	AGT	GAG	GGC
E	T	I	S	I	E	C	L	A	S	E	G
ATT	TCC	AGT	TAT	TTA	GCG	TGG	TAT	CAG	CAG	AAG	CCA
I	S	S	Y	L	A	W	Y	Q	Q	K	P
GGG	AAA	TCT	CCT	CAG	CTC	CTG	ATC	TAT	GGT	GCA	AAT
G	K	S	P	Q	L	L	I	Y	G	A	N
AGC	TTG	CAA	ACT	GGG	GTC	CCA	TCA	CGG	TTC	AGT	GGC
S	L	Q	T	G	V	P	S	R	F	S	G
AGT	GGA	TCT	GCC	ACA	CAA	TAT	TCT	CTC	AAG	ATC	AGC
S	G	S	A	T	Q	Y	S	L	K	I	S
AGC	ATG	CAA	CCT	GAA	GAT	GAA	GGG	GAT	TAT	TTC	TGT
S	M	Q	P	E	D	E	G	D	Y	F	C
CAA	CAG	AGT	TAC	AAG	TTT	CCG	AAC	ACG	TTT	GGA	GCT
Q	Q	S	Y	K	F	P	N	T	F	G	A
GGG	ACC	AAG	CTG	GAA	CTG	AAA	CGG				
G	T	K	L	E	L	K	R				

SEQ ID NO:7  
SEQ ID NO:8

Framework 1

	1	1112	2	
	9	5	7890	2
hu gp1	DIQMTQSPSSL	SASVGD	RVITC	SEQ ID NO:9
39D10	DIQMTQSPASL	SASLGETISIEC		SEQ ID NO:10

Framework 2

	4	4	
	3	5	
hu gp1	WYQQKPGKAPKLLIY		SEQ ID NO:11
39D10	WYQQKPGKSPQLLIY		SEQ ID NO:12

Framework 3

	6	777	7	888	8
	8	012	4	8	345
hu gp1	GVPSRFGSGSGTDF	TLTISSLQPEDF	FATYIC		SEQ ID NO:13
39D10	GVPSRFGSGSATQYSLKISSM	QPEDEGDYFC			SEQ ID NO:14

Framework 4

	1	1	1
	0	0	0
	0	4	6
hu gp1	FGQGTKVEIKR		SEQ ID NO:15
39D10	FGAGTKLELKR		SEQ ID NO:16

FIG.3

Framework 1

	111	1	2	22	2223	
hu gp3						EVQLVESGGGLVQPGGSLRLSCAASGFTFS SEQ ID NO:17
39D10	567	9	1	34	7890	?????ESGGGLVQPSQTL <del>SLT</del> CTVSGLSLT SEQ ID NO:18

Framework 2

	3	4	44
hu gp3			WVRQAPGKLEWVS SEQ ID NO:19
39D10	7	0	89
			WIRQPPGKLEWNG SEQ ID NO:20

Framework 3

	66	7	7777	8	88	8	9
hu gp3							RFTISRDNKNTLYLQMNLSLRAEDTAVYYCAR SEQ ID NO:21
39D10	78	3	6789	1	34	9	1
							RLSISRDTSKSQVFLKMNLSLQSEDTAM <del>Y</del> FCAR SEQ ID NO:22

Framework 4

	11
hu gp3	WGQGLVTVSS SEQ ID NO:23
39D10	78
	00
	WGQGVMTVSS SEQ ID NO:24

FIG.4

FIG.5

TTCGAAGCCGCCACC ATG TCT GTC CCC ACC CAA GTC CTC  
M S V P T Q V L

GGT CTC CTG CTG CTG TGG CTT ACA GAT GCC AGA TGT  
G L L L L W L T D A R C

GAC ATT CAA ATG ACC CAG AGC CCA TCC AGC CTG AGC  
D I Q M T Q S P S S L S

GCA TCT GTA GGA GAC CGG GTC ACC ATC ACA TGT CTA  
A S V G D R V T I T C L

GCA AGT GAG GGC ATC TCC AGT TAC TTA GCG TGG TAC  
A S E G I S S Y L A W Y

CAG CAG AAG CCC GGG AAA GCT CCT AAG CTC CTG ATC  
Q Q K P G K A P K L L I

TAT GGT GCG AAT AGC TTG CAG ACT GGA GTA CCA TCA  
Y G A N S L Q T G V P S

AGA TTC AGT GGC TCA GGA TCC GCT ACA GAC TAC ACG  
R F S G S G S A T D Y T

CTC ACG ATC TCC AGC CTA CAG CCT GAA GAT TTC GCA  
L T I S S L Q P E D F A

ACG TAT TAC TGT CAA CAG TCG TAT AAG TTC CCG AAC  
T Y Y C Q Q S Y K F P N

ACA TTC GGT CAA GGC ACC AAG GTC GAA GTC AAA CGT  
T F G Q G T K V E V K R>

SEQ ID NO:25

SEQ ID NO:26

FIG.6

AAGCTTGCCGCCACC ATG GGC TGG AGC TGT ATC ATC CTC  
M G W S C I I L

TTC TTA GTA GCA ACA GCT ACA GGT GTC CAC TCC GAG  
F L V A T A T G V H S E

GTC CAA CTG GTA GAA TCT GGA GGT GGT CTC GTA CAG  
V Q L V E S G G G L V Q

CCA GGA GGA TCT CTG CGA CTG AGT TGC GCC GTC TCT  
P G G S L R L S C A V S

GGG TTA TCA TTA ACT AGT AAT AGT GTG AAC TGG ATA  
G L S L T S N S V N W I

CGG CAA GCA CCT GGC AAG GGT CTC GAG TGG GTT GGA  
R Q A P G K G L E W V G

CTA ATA TGG AGT AAT GGA GAC ACA GAT TAT AAT TCA  
L I W S N G D T D Y N S

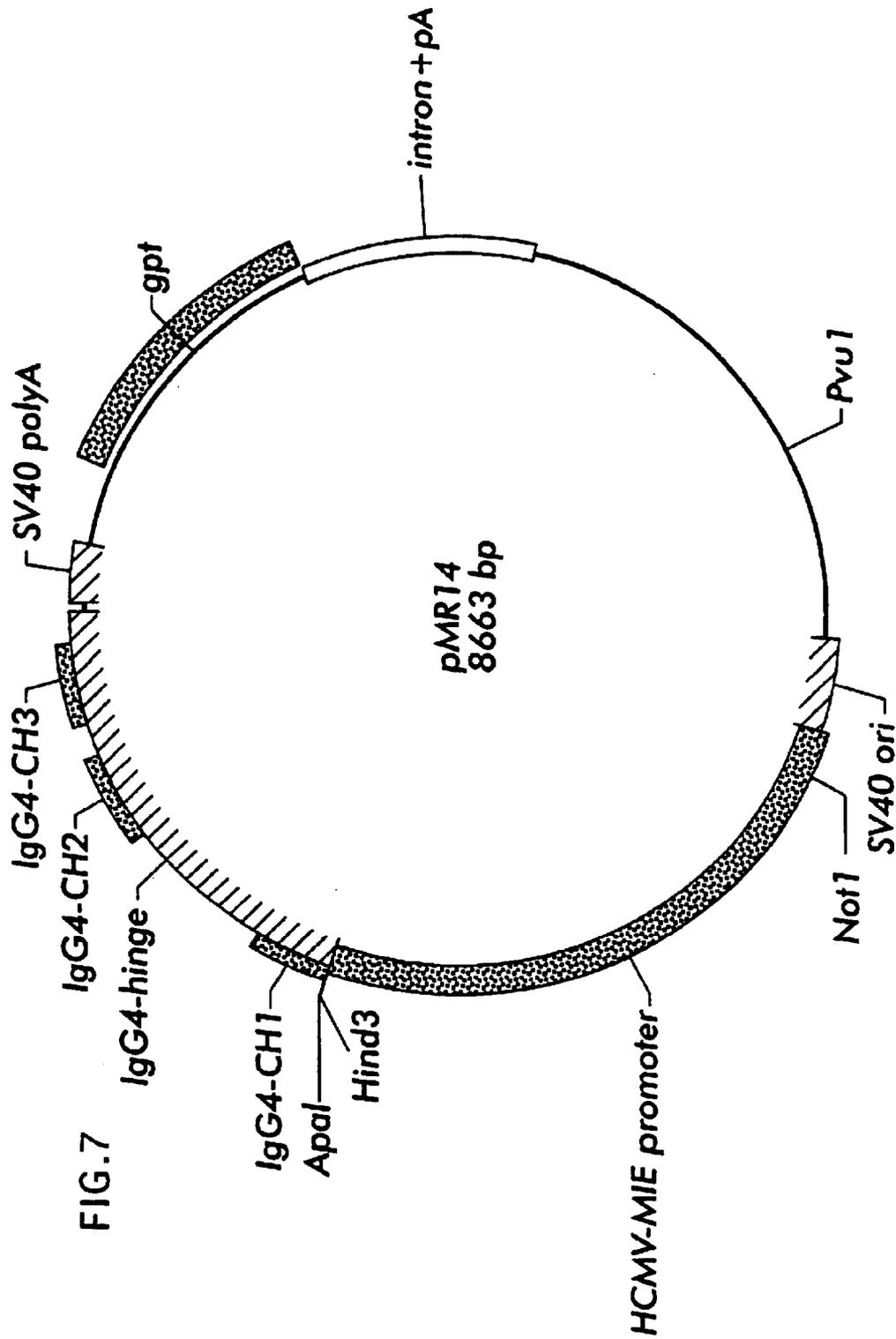
GCT ATC AAA TCT CGA TTC ACA ATC TCT AGA GAC ACT  
A I K S R F T I S R D T

TCG AAG AGC ACC GTA TAC CTG CAG ATG AAC AGT CTG  
S K S T V Y L Q M N S L

AGA GCT GAA GAT ACT GCA GTC TAC TAC TGT GCT CGT  
R A E D T A V Y Y C A R

GAG TAC TAT GGA TAT TTC GAC TAT TGG GGT CAA GGT  
E Y Y G Y F D Y W G Q G

ACC CTA GTC ACA GTC TCC TCA SEQ ID NO:27  
T L V T V S S SEQ ID NO:28



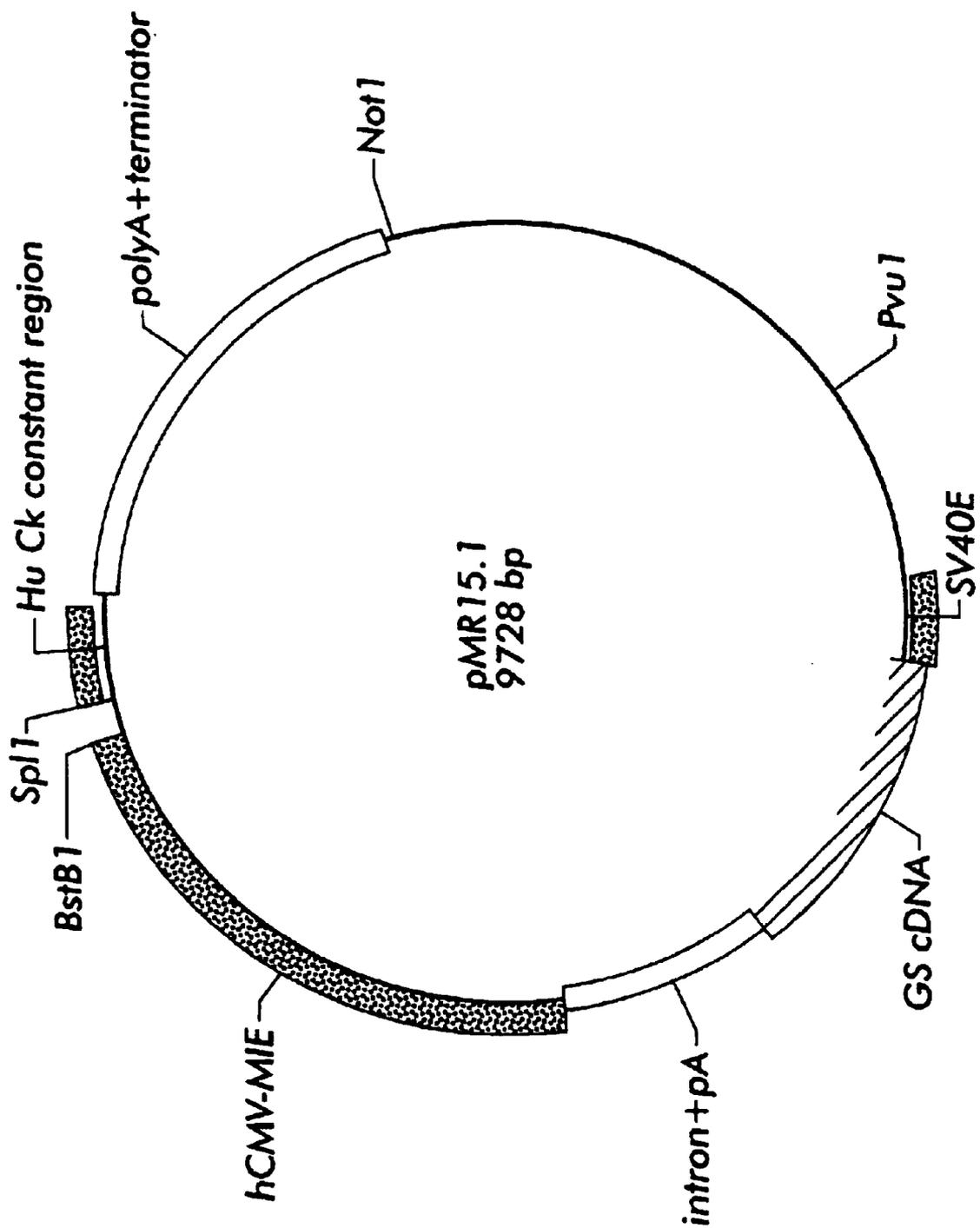


FIG. 8

FIG. 9

<u>Antibody</u>	<u>kd</u>	<u>kass</u>
	( $\times 10^{-10} \text{M}$ )	( $\times 10^5 \text{M}^{-1} \text{sec}^{-1}$ )
Chimeric 39D10	1.14	5.77
	0.63	6.27
CTIL-5-10gH/gL6	0.89	4.55
	1.18	4.72

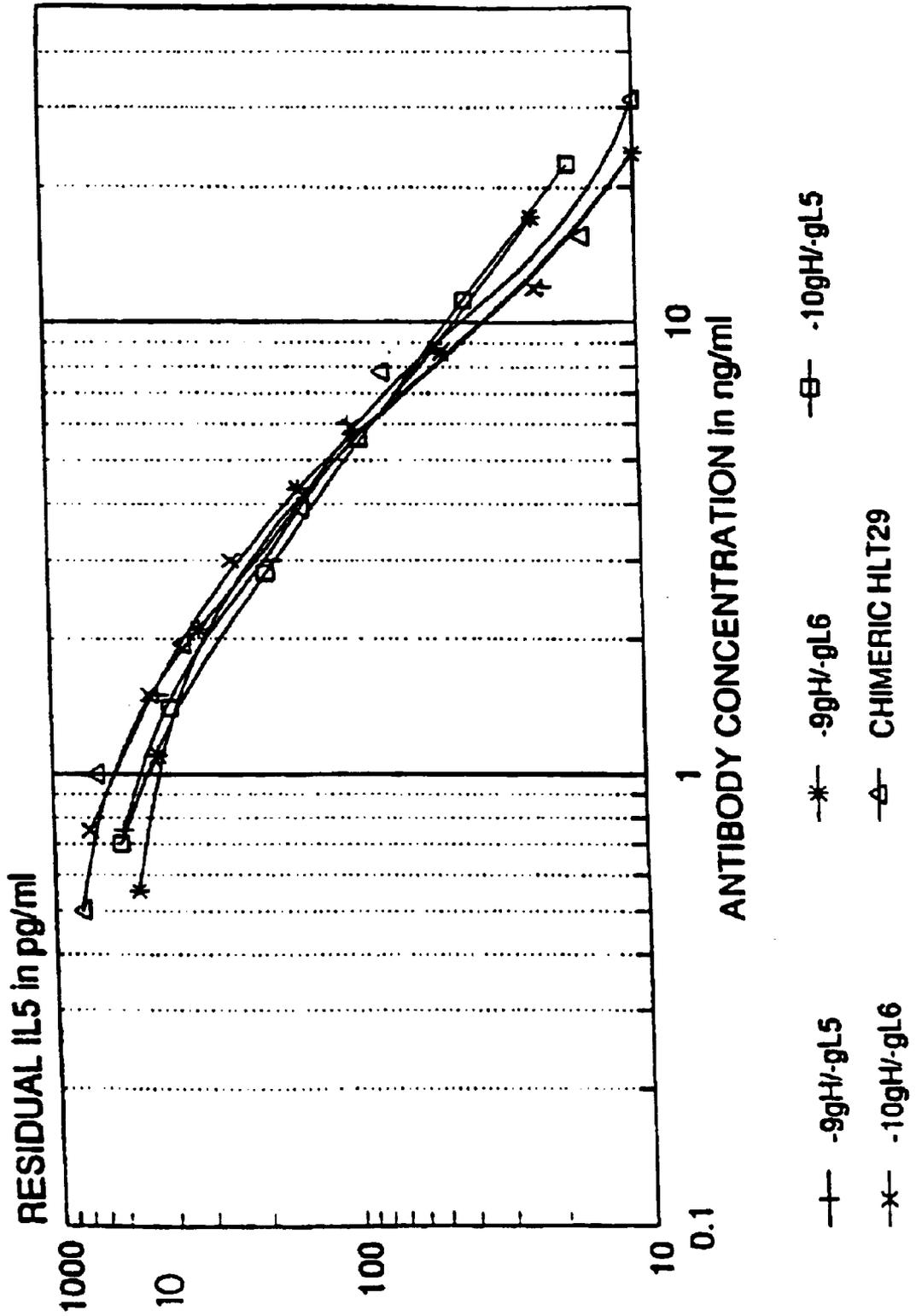
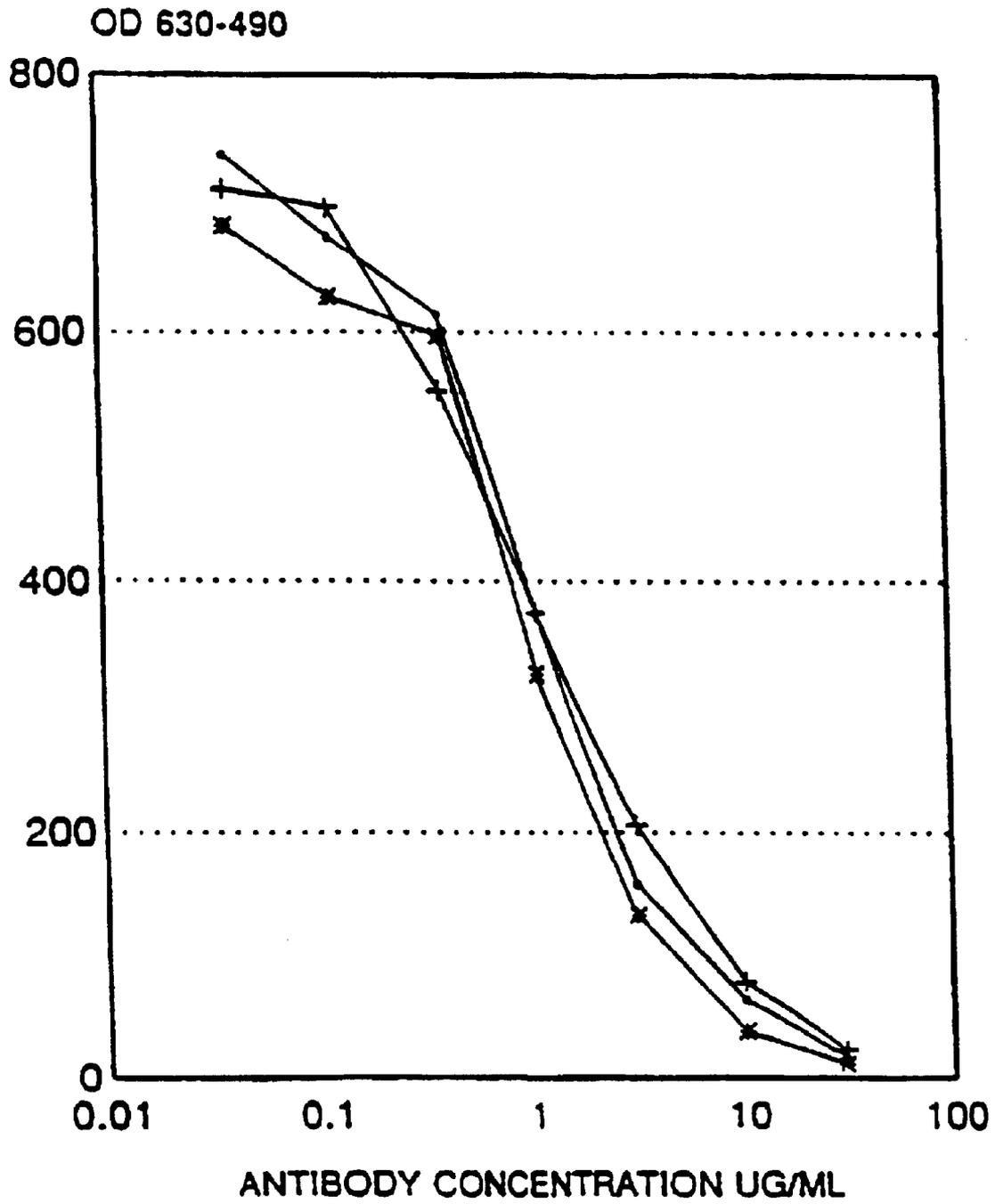


FIG. 10

FIG. 11



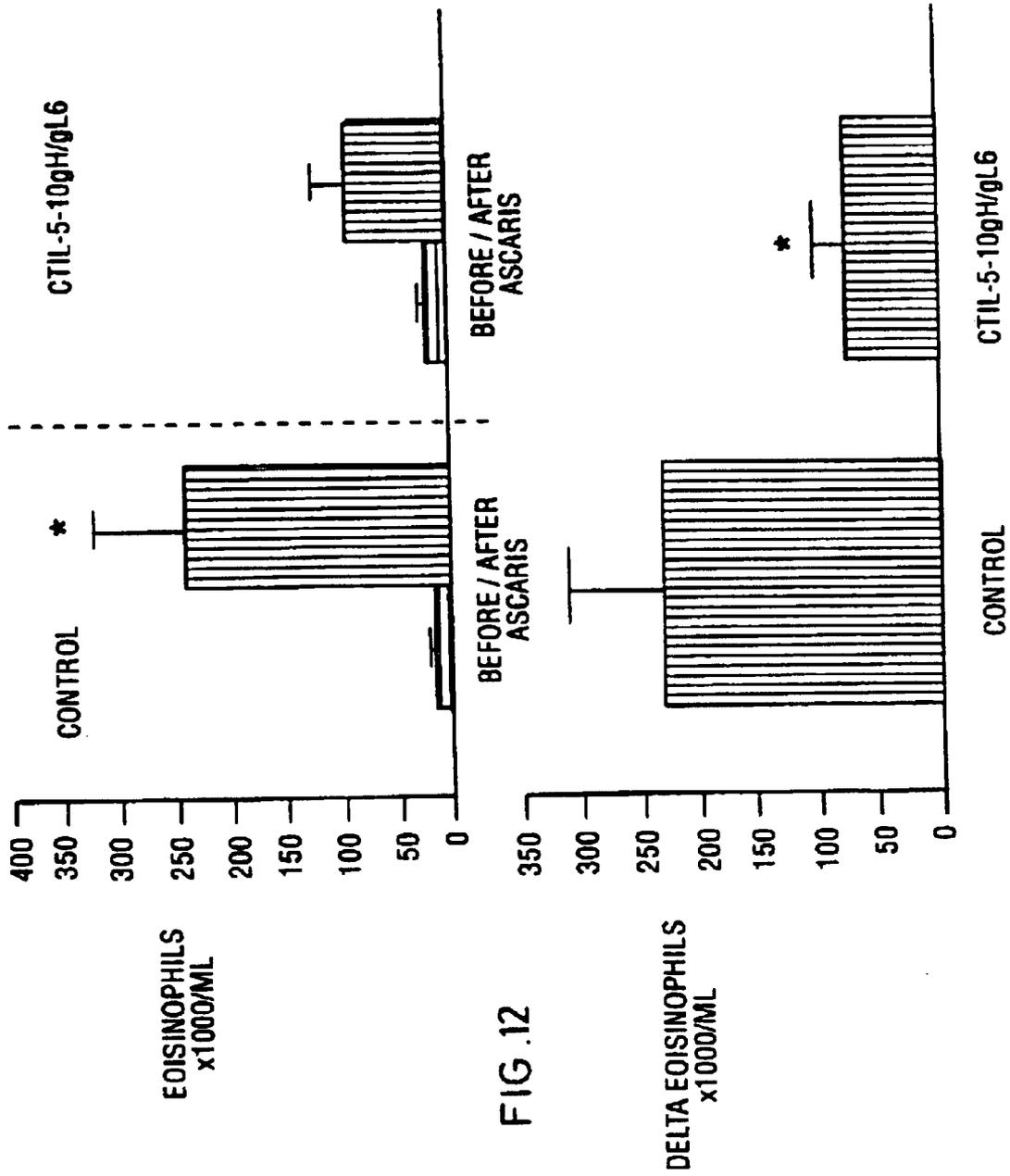


FIG. 12

## INTERLEUKIN-5 SPECIFIC RECOMBINANT ANTIBODIES

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

The present invention relates to a recombinant antibody molecule (RAM), and especially a humanized antibody molecule (HAM) having specificity for human interleukin-5 (hIL-5), the nucleic acids which encode the heavy and light chain variable domains of said recombinant antibody, a process for producing said antibody using recombinant DNA technology and the therapeutic use of the recombinant antibody.

In the present application, the term "recombinant antibody molecule" (RAM) is used to describe an antibody produced by a process involving the use of recombinant DNA technology. The term "humanized antibody molecule" (HAM) is used to describe a molecule being derived from a human immunoglobulin. The antigen binding site may comprise either complete variable domains fused onto constant domains or one of more complementary determining regions (CDRs) grafted onto appropriate framework regions in the variable domain. The abbreviation "MAb" is used to indicate a monoclonal antibody.

The term "recombinant antibody molecule" includes not only complete immunoglobulin molecules but also any antigen binding immunoglobulin fragments, such as Pv, Fab and F(ab')<sub>2</sub> fragments, and any derivatives thereof, such as single chain Fv fragments.

Natural immunoglobulins have been used in assay, diagnosis and, to a limited extent, therapy. The use of immunoglobulins in therapy has been hindered as most antibodies of potential use as therapeutic agents are MAbs produced by fusions of a rodent spleen cells with rodent myeloma cells. These MAbs are therefore essentially rodent proteins. The use of these MAbs as therapeutic agents in human can give rise to an undesirable immune response termed the HAMA (Human Anti-mouse Antibody) response. The use of rodent MAbs as therapeutic agents in humans is inherently limited by the fact that the human subject will mount an immunological response to the MAb which would either remove it entirely or at least reduce its effectiveness.

A number of techniques to reduce the antigenic characteristics of such non-human MAbs have been developed. These techniques generally involve the use of recombinant DNA technology to manipulate DNA sequences encoding the polypeptide chains of the antibody molecule. These methods are generally termed "humanization" techniques.

Early methods for humanizing MAbs involved the production of chimeric antibodies in which an antigen binding site comprising the complete variable domains of one antibody are fused to constant domains derived from another antibody. Methods for carrying out such chimerisation procedures are described in EP 0120694 (Celltech Limited) and EP 0125023 (Genetech Inc. and City of Hope). Humanized chimeric antibodies, however, still contain a significant portion of non-human amino acid sequences, and can still elicit some HAMA response, particularly if administered over a prolonged period [Begent et al. Br. J. Cancer, 62, 487 (1990)].

An alternative approach described in EP-A-0239400 (Winter), involves the grafting of the complementarity determining region (CDRs) of a mouse MAb on to framework regions of the variable domains of a human immunoglobulin

using recombinant DNA techniques. There are three CDRs (CDR1, CDR2 and CDR3) in each of the heavy and light chain variable domains. Such CDR-grafted humanized antibodies are much less likely to give rise to a HAMA response than humanized chimeric antibodies in view of the much lower proportion of non-human amino acid sequences which they contain. In Riechmann et al [Nature, 332 323-324 (1988)] it was found that the transfer of the CDRs alone, as defined by Kabat [Sequences or Proteins of Immunological Interest. US Department of Health and Human Services. NTH, USA (1987)], was not sufficient to provide satisfactory antigen binding activity in the CDR-grafted product. Riechmann et al. found that it was necessary to convert a number of residues outside the CDRs, in particular in the loop adjacent CDR1. However, the binding affinity of the best CDR-grafted antibodies obtained was still significantly less than that of the original MAb.

In WO 91/09967, Adair et al. described CDR-grafted antibody heavy and light chains, and determined a hierarchy of donor residues.

In WO 93/16184, Chou et al. described the design, cloning and expression of humanized monoclonal antibodies against human interleukin-5. A method for selecting human antibody sequences to be used as human frameworks for humanization of an animal antibody is suggested, comprising the steps of comparing human variable domain sequences with the variable domain sequences of the animal MAb that is to be humanized for percentage identities, sequence ambiguities and similar PIN-region spacing, PIN-region spacing is defined as the number of residues between the cysteine residues forming the intra domain disulfide bridges. The human antibody having the best combination of these features is selected. A method for determining which variable domain residues of an animal MAb which should be selected for humanization is also suggested, comprising determining potential minimum residues (residues which comprise CDR structural loops and the residues required to support and/or orientate the CDR structural loops) and maximum residues (residues which comprise Kabat CDRs, CDR structural loops, residues required to support and/or orientate the CDR structural loops and residues which fall within about 10 Å of a CDR structural loop and possess a water solvent accessible surface of about 5 Å<sup>2</sup> or greater) of the animal monoclonal antibody. Furthermore, computer modelling is performed on all possible recombinant antibodies, comprising the human antibody framework sequence into which minimum and maximum residues have been inserted. The minimum or maximum residues are selected based on the combination which produces a recombinant antibody having a computer-model structure closest to that of the animal monoclonal antibody. The humanized and-IL-5 antibody obtained appears to have lost a substantial amount of its affinity for the hIL-5 molecule.

It is an aim of the present invention to provide a humanized antibody molecule having improved affinity for the hIL-5 molecule.

Accordingly the present invention provides a RAM having affinity for human IL-5 and comprising antigen binding regions derived from heavy and/or light chain variable domains of a donor antibody having affinity for human IL-5, the RAM having a binding affinity similar to that of the donor antibody.

The RAM of invention may comprise antigen binding regions from any suitable donor anti-IL5 antibody. Typically the donor anti-IL-5 antibody is a rodent MAb. Preferably the donor antibody is MAb 39D10.

The variable domains of the heavy and light chains of MAb 39D10 are hereinafter specifically described with reference to FIGS. 1 and 2.

According to one preferred aspect of the invention, the RAM of the present invention is an anti-IL-5 antibody molecule having affinity for the human IL-5 antigen comprising a composite heavy chain and a complementary light chain, said composite heavy chain having a variable domain comprising predominantly acceptor antibody heavy chain framework residues and donor antibody heavy chain antigen-binding residues, said donor antibody having affinity for human IL-5, wherein said composite heavy chain comprises donor residues at least at positions 31-35, 50-65 and 95-102 (according to the Kabat numbering system) [Kabat et al., sequences of Proteins of Immunological Interest, Vol I, Fifth Edition, 1991, US Department of Health and Human Services, National Institute of Health].

Preferably, the composite heavy chain framework additionally comprises donor residues at positions 23, 24, 27-30, 37, 49, 73 and 76-78 or 24, 27-30, 37, 49, 73, 76 and 78.

According to a second preferred aspect of the present invention, there is provided an anti-IL-5 antibody molecule having affinity for a human IL-5 antigen comprising a composite light chain and a complementary heavy chain, said composite light chain having a variable domain comprising predominantly acceptor antibody light chain framework residues and donor antibody light chain antigen-binding residues, said donor antibody having affinity for human IL-5, wherein said composite light chain comprises donor residues at least at positions 24-30, 50-56 and 89-97 (according to the Kabat numbering system).

Preferably, the composite light chain framework additionally comprises donor residues at positions 22, 68 and 71 or at positions 68 and 71.

According to a third preferred aspect of the present invention, there is provided an anti-IL-5 antibody molecule having affinity for a human IL-5 antigen comprising a composite heavy chain according to the first aspect of the invention and a composite light chain according to the second aspect of the invention.

Preferably, each RAM of the invention has an affinity constant for human IL-5 of greater than  $10^{-9}$ M.

It will be appreciated that the invention is widely applicable to the production of anti-IL-5 RAMs in general. Thus, the donor antibody may be any anti-IL-5 antibody derived from any animal. The acceptor antibody may be derived from an animal of the same species and may even be of the same antibody class or sub-class. More usually, however, the donor and acceptor antibodies are derived from animals from different species. Typically, the donor anti-IL-5 antibody is a non-human antibody, such as rodent MAb, and the acceptor antibody is a human antibody.

Any appropriate acceptor variable framework sequence may be used having regard to class or type of the donor antibody from which the antigen binding regions are derived. Preferably, the type of acceptor framework used is of the same or similar or type as that of the donor antibody. Conveniently, the framework chosen has the most homology to the donor antibody. Preferably, the human group II gamma germ line frameworks are used for the composite heavy chain and the human group I kappa germ line frameworks are used for the composite light chains.

The constant region domains of the RAMs of the invention may be selected having regard to the proposed functions of the antibody, in particular the effector functions which may be required. For example, the constant regions domains may be human IgA, IgE, IgG or IgM domains. In particular, IgG human constant region domains may be used, especially of the IgG1 and IgG3 isotype, when the humanized antibody molecule is intended for therapeutic uses, and antibody

effector functions are required. Alternatively, IgG2 and IgG4 isotypes may be used where the humanized antibody molecule is intended for therapeutic purposes and antibody effector functions are not required, e.g. for specifically binding to and neutralizing the biological activity of human IL-5. Modified human constant region domains may also be used in which one or more amino acid residues have been altered or deleted to change a particular effector function. Preferably, the constant region domains of the RAMs are human IgG4.

The residue designations given above and elsewhere in the present application are numbered according to the Kabat numbering [Kabat et al. Sequences of Proteins of Immunological Interest, Vol I, Fifth Edition, 1991, US Department of Health and Human Services, National Institute of Health]. Thus, the residue designations do not always correspond directly with a linear numbering of the amino acid residues. The actual linear amino acid sequence may contain fewer or additional amino acids than in the Kabat numbering, corresponding to a shortening of, or insertion into, the basic variable domain structure.

Also the anti-IL-5 antibody molecules of the present invention may have attached to them effector or reporter molecules. Alternatively, the procedure of recombinant DNA technology may be used to produce immunoglobulin molecules in which the Fc fragment or CH3 domain of a complete immunoglobulin has been replaced by, or has been attached thereto by peptide linkage, a functional non-immunoglobulin protein, such as an enzyme, cytokine, growth factor or toxin molecule.

Thus, the remainder of the antibody molecules need not comprise only sequences from immunoglobulins. For instance, a gene may be constructed in which a DNA sequence encoding part of a human immunoglobulin chain is fused to a DNA sequence encoding the amino acid sequence of a polypeptide effector or reporter molecule.

Further aspects of the invention include DNA sequences coding for the composite heavy chain and the composite light chain. The cloning and expression vectors containing the DNA sequences, host cells transformed with the DNA sequences and the processes for producing the antibody molecules comprising expressing the DNA sequences in the transformed host cells are also further aspects of the invention.

The general methods by which vectors may be constructed, transfection methods and culture methods are well known in the art and form no part of the invention.

The DNA sequences which encode the anti-IL-5 donor amino acid sequences may be obtained by methods well known in the art (see, for example, International Patent Application No. WO 93/16184). For example, the anti-IL-5 coding sequences may be obtained by genomic cloning or cDNA cloning from suitable hybridoma cell lines, e.g. the 39D10 cell line. Positive clones may be screened using appropriate probes for the heavy and light chains required. Also PCR cloning may be used.

The DNA coding for acceptor amino acid sequences may be obtained in any appropriate way. For example, DNA sequences coding for preferred human acceptor frameworks such as human group I light chains and human group III heavy chains, are widely available to workers in the art.

The standard techniques of molecules biology may be used to prepare the desired DNA sequences. The sequences may be synthesized completely or in part using oligonucleotide synthesis techniques. Site-directed mutagenesis and polymerase chain reaction (PCR) techniques may be used as appropriate. For example, oligonucleotide directed synthesis

as described by Jones et al. [Nature, 321, 522 (1986)] may be used. Also oligonucleotide directed mutagenesis of a pre-existing variable regions as, for example, described by Verhoeyen et al. [Science, 239, 1534-1536 (1988)] may be used. Also enzymatic filling in of gapped oligonucleotides using T4 DNA polymerase as, for example, described by Queen et al. [Proc. Natl. Acad. Sci. USA, 86, 10029-10033 (1989) and WO 90/07861] may be used.

Any suitable host cell and vector system may be used for the expression of DNA sequences coding for the RAM. Preferably, eucaryotic, e.g. mammalian, host cell expression systems are used. In particular, suitable mammalian host cells include CHO cells and myeloma or hybridoma cell lines.

Thus, according to a further aspect of the present invention a process for producing an anti-IL-5 RAM is provided comprising:

(a) producing in a first expression vector a first operon having a DNA sequence which encodes a composite heavy chain, as defined according to the first preferred aspect of the invention;

(b) optionally producing in the first or a second expression vector a second operon having a DNA sequence which encodes a complementary light chain, which may be a composite light chain as defined according to the second preferred aspect of the invention;

(c) transfecting a host cell with the or each vector; and

(d) culturing a transfected cell line to produce the RAM.

Alternatively, the process may involve the use of sequences encoding a composite light chain and a complementary heavy chain.

For the production of RAMs comprising both heavy and light chains, the cell lines may be transfected with two vectors. The first vector may contain an operon encoding a composite or complementary heavy chain and the second vector may contain an operon encoding a complementary or composite light chain. Preferably, the vectors are identical except insofar as the coding sequences and selectable markers are concerned so as to ensure as far as possible that each polypeptide chain is equally expressed. In a preferred alternative, a single vector may be used, the vector including the sequences encoding both the heavy chain and the light chain.

The DNA in the coding sequences for the heavy and light chains may comprise cDNA or genomic DNA or both.

The present invention also includes therapeutic and diagnostic compositions comprising the RAMS and uses of such compositions in therapy and diagnosis.

Accordingly, in a further aspect the invention provides a therapeutic or diagnostic composition comprising a RAM according to previous aspects of the invention in combination with a pharmaceutically acceptable excipient, diluent or carrier.

These compositions can be prepared using the RAMs of the present invention, for instance as whole antibodies, single chain Pv fragments or antibody fragments, such as Fab or Fv fragments. Such composition have IL-5 blocking or antagonistic effects and can be used to suppress IL-5 activity.

The compositions according to the invention may be formulated in accordance with conventional practice for administration by any suitable route, and may generally be in a liquid form [e.g. a solution of the RAM in a sterile physiologically acceptable buffer] for administration by for example an intravenous, intraperitoneal or intramuscular route; in spray form, for example for administration by a nasal or buccal route; or in a form suitable for implantation.

The invention also provides a method of therapy or diagnosis comprising administering an effective amount, preferably 0.1 to 10 mg/kg body weight, of a RAM according to previous aspects of the invention to a human or animal subject. The exact dosage and total dose will vary according to the intended use of the RAM and on the age and condition of the patient to be treated. The RAM may be administered as a single dose, or in a continuous manner over a period of time. Doses may be repeated as appropriate.

The RAM according to previous aspects of the invention may be used for any of the therapeutic uses for which anti-IL-5 antibodies, e.g. 39D10, have been used or may be used in the future.

IL-5 is a primary activator of eosinophils, and blocking the function of this cytokine with antibodies has been shown to prevent or reduce eosinophilia which is associated with certain allergic diseases. Thus the RA according to the invention may be used for this purpose, and in particular may be of use in the treatment of asthma, where it may be expected to prevent the accumulation and activation of eosinophils in asthmatic lungs, thereby reducing bronchial inflammation and airway narrowing. For use in the treatment of asthma the RAM according to the invention may advantageously be a single chain Fv fragment, formulated as a spray, for administration for example via the nasal route.

A preferred protocol for obtaining an anti-IL-5 antibody molecule in accordance with the present invention is set out below. This protocol is given without prejudice to the generality of the invention as hereinbefore described and defined.

The 39D10 rat monoclonal antibody raised against human IL-5 is used as the donor antibody. The variable domains of the heavy and light chains of 39D10 have previously been cloned (WO 93/16184) and the nucleotide and predicted amino acid sequences of these domains are shown in FIGS. 1 and 2. The appropriate acceptor heavy and light chain variable domains must be determined and the amino acid sequence known. The RAM is then designed starting from the basis of the acceptor sequence.

#### 1. The CDRs

At a first step, donor residues are substituted for acceptor residues in the CDRs. For this purpose, the CDRs are preferably defined as follows:

heavy chain:

CDR1: residues 31-35

CDR2: residues 50-65

CDR3: residues 95-102 light chain;

CDR1: residues 24-34

CDR2: residues 50 to 56

CDR3: residues 89 to 97

The positions at which donor residues are to be substituted for acceptor residues in the framework are then chosen as follows, first of all with respect to the heavy chain and subsequently with respect to the light chain.

#### 2. HEAVY CHAIN

2.1. Donor residues are used either at all of positions 24, 27 to 30, 37, 49, 73, 76 and 78 or at all of positions 23, 24, 27 to 30, 37, 49, 73 and 76 to 78 of the heavy chain.

#### 3. LIGHT CHAIN

3.1. Donor residues are used either at all of positions 22, 68 and 71 or at all of positions 68 and 71.

The present invention relates to a recombinant anti-IL-5 antibody molecule having a binding affinity substantially equal to that of the donor antibody. The present invention is

now described, by way of example only, with references to the accompanying drawings, in which:

FIG. 1 shows the nucleotide and amino acid sequence of the 39D10 heavy chain;

FIG. 2 shows the nucleotide and amino acid sequence of the 39D10 light chain;

FIG. 3 shows the alignment of the 39D10 *light*[heavy]chain variable domain framework regions with the *light*[heavy]chain variable domain framework regions of the consensus sequence of the human group I/III *light*[heavy]chains;

FIG. 4 shows the alignment of the 39D10 *heavy*[light]chain variable domain framework regions with the *heavy*[light]chain variable domain framework regions of

the consensus sequence of the human group III/I *heavy*[light]chains;

FIG. 5 shows the nucleotide and amino acid sequence of the CDR grafted anti-IL-5 light chain CTIL-5-gL6[.]. The first twenty amino acid residues of SEQ ID No: 26 represent a leader sequence. The first amino acid residue of the mature protein is residue 21.

FIG. 6 shows the nucleotide and amino acid sequence of the CDR grafted anti-IL-5 heavy chain CTIL-5-10gH[.]. The first nineteen amino acid residues SEQ ID No: 28 represent a leader sequence. The first amino acid residue of the mature protein is residue 20.

FIG. 7 shows a map of plasmid pMR14;

FIG. 8 shows a map of plasmid pMR15.1;

FIG. 9 shows the affinity constants and association and disassociation rates of a chimeric 39D10 antibody and the CTIL-5-10gH-gL6 antibody;

FIG. 10 shows a graph of the neutralisation of IL-5 in the TF1 assay by a panel of antibodies;

FIG. 11 shows the results of a competition assay for rat 39D10, a chimeric 39D10 antibody and the CTIL-5-10gH/gL6 antibody; and

FIG. 12 shows the effect of CTIL-5-10gH/gL6 on monkey eosinophilia.

## EXAMPLE

### 1. MATERIAL AND METHODS

39D10 is a rat monoclonal antibody raised against human IL-5. The genes for the variable domains of the heavy and light chains of 39D10 have previously been cloned (WO 93/16184) and the nucleotide and predicted amino acid sequences of these domains are shown in FIGS. 1 and 2. Because of the strategy used in the cloning of the variable domain of the 3gD10 heavy chain, the first five amino acids of the framework regions are unknown. However, a heavy chain was available which contained the leader sequence and the first five amino acids of framework 1 from the antibody YTH 34.5HL. Riechmann et al., [Nature, 332, 323-327 (1988)].

### 2. MOLECULAR BIOLOGY PROCEDURES

The molecular biology procedures used were as described in Maniatis et al. [Molecular Cloning: A Laboratory Manual,

Second Edition, Vols 1 to 3. Cold Spring Harbor Laboratory Press (1989) .

### 3. CONSTRUCTION OF RECOMBINANT HEAVY AND LIGHT CHAIN GENES

#### Heavy Chain

A heavy chain Vh region was generated by PCR using the oligonucleotides R3601 and R2155. The sequences of these are:

R3601 5'GCGCGCAAGCTTGCGCCACCATGAAG(A, T)TGTGGTTAAACTGGGTTT3' SEQ ID NO:1

R2155 5'GCAGATGGGCCCTTCGTTGAGGCTG(A, C)(A, G)GAGAC(G, T, A) SEQ ID NO:2

The reaction mixture (100 µl) contained 10 mM Tris-HCl pH 8.3, 1.5 mM MgCl<sub>2</sub>, 50 mM KCl, 0.01% w/v gelatin, 0.25 mM of each deoxyribonucleoside triphosphate, 0.1 µg 39D10 heavy chain DNA, 6 pmoles of R3601 and R2155 and 0.25 units. Taq polymerase. The reaction mixture was heated at 94° C. for 5 minutes and then cycled through 94° C. for 1 minute, 55° C. for 1 minute and 72° C. for 1 minute. After 30 cycles, the reaction was extracted with an equal volume of phenol/chloroform (1:1 v/v), then with chloroform before being precipitated by the addition of 2.5 volumes of ethanol. The PCR product was dissolved in the appropriate buffer, digested with HindIII and ApaI, purified on an agarose gel and ligated into the vector pMR14 (FIG. 7) which had also been digested with HindIII and ApaI. Following transformation into *E. coli* LM1035, colonies were grown overnight and plasmid DNA analysed for Vh inserts. The nucleotide sequence of the Vh region in plasmid, pARH1217, is shown in FIG. 1.

#### Light Chain

A V<sub>L</sub> light chain gene was generated from the original VL as described in WO 93/16184, clone by PCR with the oligonucleotides R3585 and R3597. The sequence of these are:

R3585 5'GGACTGTTCGAAGCCGCCACCATGAGTGTGCTCACTCAGGTCT3' SEQ ID NO:3

R3597 5'GGATACAGTTGGTGCAGCATCCGTACGTTT3' SEQ ID NO:4

PCR was carried out as described above. The PCR product was digested with enzymes BstBI and SphI and, after purification, ligated into pMR15.1 (FIG. 8) that had previously been digested with the same enzymes.

A colony was identified, after transformation of *E. coli* LM1035, that contained a plasmid (pARH1215) with a V<sub>L</sub> insert. The nucleotide sequence of the V<sub>L</sub> insert is shown in FIG. 2.

#### CDR Grafting of 39D10

##### Light Chain

In order to decide on the most appropriate human acceptor frameworks for the CDR loops of 39D10, the main acid sequence of frameworks 1-3 of 39D10 were compared with those of known human kappa light chains. 39D10 was found to be most homologous to human group I light chains. Based on this, it was decided to use the human group I germ line frameworks for the CDR grafting. The homologies between these sequences are shown in FIG. 3. Also shown is the

homology between the framework 4 regions of 39D10 and the consensus sequence of known human group I light chains. The residues in 39D10 that differ from the human consensus sequence are underlined. The contribution that these residues might make to antigen binding was analysed and two genes were constructed for the CDR grafted light chain. These were CTIL-5gL5 and CTIL-5gL6 in which, as well, as the CDR residents, either residues 22, 68 and 71 or residues 68 and 71 were also from 39D10 respectively. The nucleotide and amino acid sequences of CTIL-5-gL6 are shown in FIG. 5.

#### Heavy Chain

CDR grafting of the 39D10 heavy chain was carried out as described for the light chain. The framework regions of 39D10 were found to be most homologous to those of human group III antibodies and, consequently, the consensus sequence of the frameworks of the human group III germ line genes was used to accept the CDRs of the 39D10 heavy chain. As before, the consensus sequence for human group III framework 4 regions was also chosen. A comparison of these sequences is shown in FIG. 4 with the residues in 39D10 that differ from the human consensus sequence underlined.

Analysis of the framework residues in 39D10 that might influence antigen binding was carried out and, based on this, two genes, CTIL-5-9gH and CTIL-5-10gH, were constructed in which either residues 23, 24, 27 to 30, 37, 49, 73 and 76 to 78 or residues 24, 27-30, 37, 49, 73, 76 and 78 respectively were from 39D10. The nucleotide and amino acid sequences of CTIL-5-10gH is shown in FIG. 6.

#### Expression and Bioactivity of Anti-IL-5 Antibodies

Chimeric (rat/human) and CDR grafted 39D10 were produced for biological evaluation by transient expression of the heavy and light chain pairs after co-transfection into Chinese Hamster ovary (CHO) cells using calcium phosphate precipitation.

On the day prior to transfection, semi-confluent flasks of CHO-L76lh cells (Cockett et al. Nucl. Acids. Res., 19, 319-325, 1991) were trypsinised, the cells counted and T75 flasks set up each with  $10^7$  cells. On the next day, the culture medium was changed 3 hours before transfection. For transfection, the calcium phosphate precipitate was prepared by mixing 1.25 ml of 0.25 M  $\text{CaCl}_2$  containing 50  $\mu\text{g}$  of each of heavy and light chain expression vectors with 1.25 ml of  $2 \times \text{HBS}$  (16.36 g NaCl, 11.9 gm HEPES and 0.4 g  $\text{Na}_2\text{HPO}_4$  in 1 liter water with the pH adjusted to 7.1 with NaOH) and adding immediately into the medium of the cells. After 3 hours at 37° C. in a  $\text{CO}_2$  incubator, the medium and precipitate were removed and the cells shocked by the addition of 15 ml 15% glycerol in phosphate buffered saline (PBS) for 1 minute. The glycerol was removed, the cells washed once with PBS and incubated for 48-96 hours in 25 ml medium containing 10 KM sodium butyrate. Antibody was purified from the culture medium by binding to and elution from protein A-Sepharose. Antibody concentration was determined using a human Ig ELISA (see below).

#### ELISA

Antibody expression was assessed by transfecting pairs of heavy and light chain genes into CHO cells and, after three days incubation, measuring the amount of antibody accumulating in the culture medium by ELISA.

For the ELISA, Nunc ELISA plates were coated overnight at 4° C. with a  $\text{F(ab')}_2$  fragment of a polyclonal goat anti-human Fc fragment specific antibody (Jackson Immunoresearch, code 109-006-098) at 5  $\mu\text{g}/\text{ml}$  in coating buffer (15 mM sodium carbonate, 35 mM sodium hydrogen carbonate, pH6.9). Uncoated antibody was removed by

washing 5 times with distilled water. Samples and purified standards to be quantiated were diluted to approximately 1  $\mu\text{g}/\text{ml}$  in conjugate buffer (0.1M Tris-HCl pH7.0, 0.1M NaCl, 0.2% v/v Tween 20, 0.2% w/v Hammersten casein).

The samples were titrated in the microtiter wells in 2-fold dilutions to give a final volume of 0.1 in each well and the plates were incubated at room temperature for 1 hour with shaking. After the first incubation step, the plates were washed 10 times with distilled water and then incubated for 1 hour as before with 0.1 ml of a mouse monoclonal anti-human kappa (clone GD12) peroxidase conjugated antibody (The Binding Site, code MP135) at a dilution of 1 in 700 in conjugate buffer. The plate was washed again and substrate solution (0.1 ml) added to each well. Substrate solution contained 150  $\mu\text{l}$  N,N,N,N-tetramethylbenzidine (10 mg/ml in DMSO), 150  $\mu\text{l}$  hydrogen peroxide (30% solution) in 10 ml 0.1M sodium acetate/sodium citrate, pH6.0. The plate was developed for 5-10 minutes until the absorbance at 630 nm was approximately 1.0 for the top standard. Absorbance at 630 nm was measured using a plate reader and the concentration of the sample determined by comparing the titration curves with those of the standard. Determination of Affinity Constants for Anti-IL-5 Antibodies

Affinities of the chimeric and CDR grafted anti-IL-5 antibodies were determined using Biospecific Interaction Analysis (BIA). Antibodies were produced in CHO cells by transfection of combination of heavy and light chain genes and purified from culture supernatants on Protein A Sepharose. For affinity measurements, a polyclonal anti-human Fc antibody was bound to the Pharmacia Biosensor chip (12150 relative response units, RU) and used to capture anti-IL-5 which was passed over the chip at 5  $\mu\text{g}/\text{ml}$  in 10 mM HEPES, 0.15M NaCl, 3.4 mM EDTA, pH7.4. The amount of anti-IL-5 captured for each run was approximately 1600 RU. Recombinant human IL-5 was then passed over the Sensorchip at various concentrations (0.6 to 5  $\mu\text{g}/\text{ml}$ ) in the above buffer. The Sensorchip was cleaned after each run with 100 mM HCl and 100 mM orthophosphoric acid to remove bound IL-5 and antibody. The sensorgrams generated were analysed using the kinetics software available with the BIAcore machine.

Values for the affinity constants and association and dissociation rates of two antibodies, chimeric 39D10 and CTIL-5-10gH-gL6, were determined. The results are shown in FIG. 9. It can be seen that chimeric 39D10 has an extremely high affinity for human IL-5 and that this value has been reproduced in CTIL-5-10gH-gL6.

#### Activity of Anti-IL-5 Antibodies in in vitro Bioassay

The activities of various CDR grafted antibodies were compared with that of chimeric 39D10 in an in vitro bioassay using TF1 cells, TF1 is an erythroleukemic cell line that requires GM-CSF for growth. GM-CSF can be replaced by IL-5 but in this instance the cells only survive and do not proliferate. However the dependence on IL-5 for survival means that TF1 cells can be used in a bioassay to compare the activities of various anti-IL-5 antibodies.

Neutralisation by anti-IL-5 antibodies was measured using a constant amount of IL-5 (2 ng/ml) and variable amounts of antibody incubated with  $5 \times 10^4$  cells per well in 96 flat bottomed plates for 3 days. For the last 4 hours, cells are cultured in the presence of 500  $\mu\text{g}/\text{ml}$  Thiazolyl blue (MIT). This dye is converted into an insoluble purple form by mitochondrial enzymes in viable cells. The insoluble material was dissolved by incubating overnight after addition of 100  $\mu\text{l}$  of 50% dimethyl formamide, 20% SDS pH4.7 and the amount of dye taken up determined spectrophotometrically.

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metrically. The levels of bioactive IL-5 remaining in the presence of the antibodies is extrapolated from a standard curve relating dye uptake to IL-5 concentration.

The activities of various combination of heavy and light chains were evaluated using the TF1 bioassay. The results are shown in FIG. 10. It can be seen that all combinations of CDR grafted heavy and light chains produce antibodies that are equipotent with chimeric 39D10. These results indicate that neither residue 22 in the light chain nor residues 23 or 78 in the heavy chains are required to be 39D10 specific for optimal binding. The combination with the fewer 39D10 specific residues is therefore CTIL-5-10gH/gL6.

## Activity of Anti-IL-5 Antibodies in Competition Assays

Recombinant human IL-5 was diluted to 1 µg/ml in phosphate buffered saline (PBS) and 100 µl aliquots added to microtitre plates (Costar Amine Binding plates) and incubated overnight at 4° C. Plates were washed three times with PBS containing 0.5% Tween 20 and any remaining active sites blocked with 2% bovine serum albumin (BSA) in PBS for 30 minutes. The plates were then aspirated and tapped dry. To compare the relative binding activity of the parent rat antibody (39D10) with chimeric and grafted antibodies, serial dilutions were prepared of each anti-IL-5 antibody in PBS/1% BSA and 50 µl added to duplicate wells followed immediately by 50 µl 39D10-biotin conjugate at 0.125 µg/ml. The assay was incubated for 2 hours at room temperature with agitation and then washed twice with PBS.

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Horseradish-peroxidase conjugated to streptavidin (1 µg/ml) was added to all wells and incubated for a further 30 minutes. Plates were washed four times and 100 µl tetramethyl benzidine. (TMB) substrate added. Colour development was read at 630 nm (reference 490 nm) and OD (630-490) was plotted against log (10) antibody concentration.

When the activities of rat 39D10, chimeric 39D10 and CTIL-5-10gH/gL6 were compared in the above competition assay, the results shown in FIG. 11 were obtained. All three antibodies competed equally well with biotinylated-39D10 for binding to IL-5, indicating that the CDR loops of 39D10 had been successfully transferred to the human frameworks. Effect of Anti-IL-5 Antibody on Monkey Eosinophilia

Anti-IL-5 antibody (CTIL-5-10gH/gL6) was tested in a monkey system which models asthmatic conditions (see Mauser, P. J. et al., *Am. J. Resp. Crit. Care Med.*, 152:467-472, 1995. When administered, one hour before challenge with *Ascaris*, to responsive monkeys, CTIL-5-10gH/gL6 inhibits lung lavage eosinophilia 75% at a dose of 0.3 mg/kg i.v. This set of monkeys is not hyper-responsive to histamine so the effects of CTIL-5-10gH/gL6 on hyper-responsiveness could not be determined. Three months after this single dose, eosinophil accumulation in response to *Ascaris* challenge is still inhibited 75%.

In the allergic mouse, CTIL-5-10gH/gL6 inhibits pulmonary eosinophilia at 1 mg/kg i.p.

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 Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Met Gly Leu Ile Trp Ser  
 35 40 45  
 Asn Gly Asp Thr Asp Tyr Asn Ser Ala Ile Lys Ser Arg Leu Ser Ile  
 50 55 60  
 Ser Arg Asp Thr Ser Lys Ser Gln Val Phe Leu Lys Met Asn Ser Leu  
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Ala Ser Leu Gly Glu Thr Ile Ser Ile Gly Cys Leu Ala Ser Glu Gly
           35           40           45
Ile Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ser Pro
           50           55           60
Gln Leu Leu Ile Tyr Gly Ala Asn Ser Leu Gln Thr Gly Val Pro Ser
65           70           75           80
Arg Phe Ser Gly Ser Gly Ser Ala Thr Gln Tyr Ser Leu Lys Ile Ser
           85           90           95
Ser Met Gln Pro Glu Asp Glu Gly Asp Tyr Phe Cys Gln Gln Ser Tyr
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Met Asn Ser Leu Gln Ser Glu Asp Thr Ala Met Tyr Phe Cys Ala Arg  
20 25 30

<210> SEQ ID NO 23  
<211> LENGTH: 11  
<212> TYPE: PRT  
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 23

Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser  
1 5 10

<210> SEQ ID NO 24  
<211> LENGTH: 11  
<212> TYPE: PRT  
<213> ORGANISM: Rattus rattus

<400> SEQUENCE: 24

Trp Gly Gln Gly Val Met Val Thr Val Ser Ser  
1 5 10

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<210> SEQ ID NO 25
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<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Novel Sequence

<400> SEQUENCE: 25

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acagatgcca gatgtgacat tcaaatgacc cagagcccat ccagcctgag cgcatctgta    120
ggagaccggg tcaccatcac atgtctagca agtgagggca tctccagtta cttagcgtgg    180
taccagcaga agccccggaa agctcctaag ctctctgatct atggtgcgaa tagcttgag    240
actggagtac catcaagatt cagtggctca ggatccgcta cagactacac gctcaccgatc    300
tccagcctac agcctgaaga ttctgcaacg tattactgtc aacagtcgta taagttcccc    360
aacacattcg gtcaaggcac caaggtcgaa gtcaaactg    399

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<210> SEQ ID NO 26
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<212> TYPE: PRT
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Novel Sequence
<221> NAME/KEY: mat_peptide
<222> LOCATION: (21)..()
<223> OTHER INFORMATION:

<400> SEQUENCE: 26

Met Ser Val Pro Thr Gln Val Leu Gly Leu Leu Leu Trp Leu Thr
-20          -15          -10          -5

Asp Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser
      -1  1          5          10

Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Leu Ala Ser Glu Gly
      15          20          25

Ile Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro
      30          35          40

Lys Leu Leu Ile Tyr Gly Ala Asn Ser Leu Gln Thr Gly Val Pro Ser
45          50          55          60

Arg Phe Ser Gly Ser Gly Ser Ala Thr Asp Tyr Thr Leu Thr Ile Ser
      65          70          75

Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Ser Tyr
      80          85          90

Lys Phe Pro Asn Thr Phe Gly Gln Gly Thr Lys Val Glu Val Lys Arg
      95          100          105

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<210> SEQ ID NO 27
<211> LENGTH: 420
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Novel Sequence

<400> SEQUENCE: 27

aagcttgccg ccaccatggg ctggagctgt atcatcctct tcttagtagc aacagctaca    60
ggtgtccact ccgaggtcca actggtagaa tctggagggtg gtctcgtaca gccaggagga    120
tctctgcgac tgagttgcgc cgtctctggg ttatcattaa ctagtaatag tgtgaactgg    180
atacggcaag cacctggcaa gggctcgcag tgggttgac taatatggag taatggagac    240
acagattata attcagctat caaatctcga ttcacaatct ctagagacac ttcgaagagc    300

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-continued

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accgtatacc tgcagatgaa cagtctgaga gctgaagata ctgcagtcta ctactgtgct 360
cgtgagtact atggatattt cgactattgg ggtcaaggta ccctagtcac agtctcctca 420
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<210> SEQ ID NO 28
<211> LENGTH: 135
<212> TYPE: PRT
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Novel Sequence
<221> NAME/KEY: mat_peptide
<222> LOCATION: (20)..()
<223> OTHER INFORMATION:
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<400> SEQUENCE: 28
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Met Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly
      -15           -10           -5
Val His Ser Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln
      -1  1           5           10
Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Val Ser Gly Leu Ser Leu
      15           20           25
Thr Ser Asn Ser Val Asn Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu
      30           35           40           45
Glu Trp Val Gly Leu Ile Trp Ser Asn Gly Asp Thr Asp Tyr Asn Ser
      50           55           60
Ala Ile Lys Ser Arg Phe Thr Ile Ser Arg Asp Thr Ser Lys Ser Thr
      65           70           75
Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr
      80           85           90
Tyr Cys Ala Arg Glu Tyr Tyr Gly Tyr Phe Asp Tyr Trp Gly Gln Gly
      95           100          105
Thr Leu Val Thr Val Ser Ser
      110           115
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We claim:

1. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen comprising a composite heavy chain and a composite light chain, said composite heavy chain and light chain forming a variable domain comprising acceptor antibody framework residues, said variable domain comprising corresponding donor residues from murine monoclonal 39D10 heavy chain variable region consisting of the sequence of SEQ ID No:6 at residues 31-35, 50-65 and 95-102 and at framework residues 23, 24, 27-30, 37, 49, 73, 76, 77, and 78, and corresponding donor residues from murine monoclonal antibody 39D10 light chain variable region consisting of the sequence of SEQ ID No:8 at residues 24-34, 50-56 and 89-97 and at framework residues 22, 68, and 71 according to the Kabat numbering system.

2. An antibody molecule according to claim 1 wherein the acceptor antibody framework residues for the composite heavy chain are human group III heavy chain residues, and the acceptor antibody framework residues for the composite light chain are human group I light chain residues.

3. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen, comprising [the]a heavy chain variable region amino acid sequence comprising residues 20-135 of SEQ ID No: 28, and [the]a light chain variable region amino acid sequence comprising residues 21-128 of SEQ ID No: 26.

4. A composition comprising the antibody molecule of any one of claims 1, 2, or 3 in combination with a pharmaceutically acceptable carrier, diluent or excipient.

45 5. A recombinant antibody molecule that specifically binds human interleukin-5 antigen comprising a composite heavy chain and a composite light chain, said composite heavy chain and light chain forming a variable domain comprising acceptor antibody framework residues, said variable domain comprising corresponding donor residues from murine monoclonal antibody 39D10 heavy chain variable region consisting of the sequence of SEQ ID NO:6 at residues 31-35, 50-65 and 95-102 and at framework residues 24, 27-30, 37, 49, 73, 76 and 78, and corresponding donor residues from murine monoclonal antibody 39D10 light chain variable region consisting of the sequence of SEQ ID No:8 at residues 24-34, 50-56 and 89-97 and at framework residues 68 and 71 according to the Kabat number system.

60 6. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen, comprising a heavy chain variable region encoded by SEQ ID No: 27 and a light chain variable region encoded by SEQ ID No:25.

7. A composition comprising the antibody molecule of any one of claims 5 or 6 in combination with a pharmaceutically acceptable carrier, diluent, or excipient.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : RE 39,548 E  
APPLICATION NO. : 10/012579  
DATED : April 3, 2007  
INVENTOR(S) : Bodmer et al.

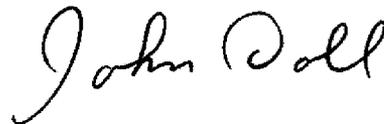
Page 1 of 15

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

PLEASE **DELETE** COLUMN 1 LINE 1 THROUGH COLUMN 24 LINE 66 AND  
**INSERT** COLUMN 1 LINE 1 THROUGH COLUMN 28 LINE 35 AS ATTACHED

Signed and Sealed this

Nineteenth Day of May, 2009



JOHN DOLL  
*Acting Director of the United States Patent and Trademark Office*

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## INTERLEUKIN-5 SPECIFIC RECOMBINANT ANTIBODIES

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

The present invention relates to a recombinant antibody molecule (RAM), and especially a humanized antibody molecule (HAM) having specificity for human interleukin-5 (hIL-5), the nucleic acids which encode the heavy and light chain variable domains of said recombinant antibody, a process for producing said antibody using recombinant DNA technology and the therapeutic use of the recombinant antibody.

In the present application, the term "recombinant antibody molecule" (RAM) is used to describe an antibody produced by a process involving the use of recombinant DNA technology. The term "humanized antibody molecule" (HAM) is used to describe a molecule being derived from a human immunoglobulin. The antigen binding site may comprise either complete variable domains fused onto constant domains or one of more complementary determining regions (CDRs) grafted onto appropriate framework regions in the variable domain. The abbreviation "MAb" is used to indicate a monoclonal antibody.

The term "recombinant antibody molecule" includes not only complete immunoglobulin molecules but also any antigen binding immunoglobulin fragments, such as Fv, Fab and F(ab)<sub>2</sub> fragments, and any derivatives thereof, such as single chain Fv fragments.

Natural immunoglobulins have been used in assay, diagnosis and, to a limited extent, therapy. The use of immunoglobulins in therapy has been hindered as most antibodies of potential use as therapeutic agents are MAbs produced by fusions of a rodent spleen cells with rodent myeloma cells. These MAbs are therefore essentially rodent proteins. The use of these MAbs as therapeutic agents in human can give rise to an undesirable immune response termed the HAMA (Human Anti-mouse Antibody) response. The use of rodent MAbs as therapeutic agents in humans is inherently limited by the fact that the human subject will mount an immunological response to the MAb which would either remove it entirely or at least reduce its effectiveness.

A number of techniques to reduce the antigenic characteristics of such non-human MAbs have been developed. These techniques generally involve the use of recombinant DNA technology to manipulate DNA sequences encoding the polypeptide chains of the antibody molecule. These methods are generally termed "humanization" techniques.

Early methods for humanizing MAbs involved the production of chimeric antibodies in which an antigen binding site comprising the complete variable domains of one antibody are fused to constant domains derived from another antibody. Methods for carrying out such chimerisation procedures are described in EP 0120694 (Celltech Limited) and EP 0125023 (Genetech Inc. and City of Hope), Humanized chimeric antibodies, however, still contain a significant portion of non-human amino acid sequences, and can still elicit some HAMA response, particularly if administered over a prolonged period [Begent et al. Br. J. Cancer, 62, 487 (1990)].

An alternative approach described in EP-A-0239400 (Winter), involves the grafting of the complementarity determining region (CDRs) of a mouse MAb on to framework regions of the variable domains of a human immunoglobulin using recombinant DNA techniques. There are three CDRs

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(CDR1, CDR2 and CDR3) in each of the heavy and light chain variable domains. Such CDR-grafted humanized antibodies are much less likely to give rise to a HAMA response than humanized chimeric antibodies in view of the much lower proportion of non-human amino acid sequences which they contain. In Riechmann et al [Nature, 332 323-324 (1988)] it was found that the transfer of the CDRs alone, as defined by Kabat (Sequences or Proteins of Immunological Interest. US Department of Health and Human Services. NTH, USA (1987)), was not sufficient to provide satisfactory antigen binding activity in the CDR-grafted product. Riechmann et al. found that it was necessary to convert a number of residues outside the CDRs, in particular in the loop adjacent CDR1. However, the binding affinity of the best CDR-grafted antibodies obtained was still significantly less than that of the original MAb.

In WO 91/09967, Adair et al. described CDR-grafted antibody heavy and light chains, and determined a hierarchy of donor residues.

In WO 93/16184, Chou et al. described the design, cloning and expression of humanized monoclonal antibodies against human interleukin-5. A method for selecting human antibody sequences to be used as human frameworks for humanization of an animal antibody is suggested, comprising the steps of comparing human variable domain sequences with the variable domain sequences of the animal MAb that is to be humanized for percentage identities, sequence ambiguities and similar PIN-region spacing, PIN-region spacing is defined as the number of residues between the cysteine residues forming the intra domain disulfide bridges. The human antibody having the best combination of these features is selected. A method for determining which variable domain residues of an animal MAb which should be selected for humanization is also suggested, comprising determining potential minimum residues (residues which comprise CDR structural loops and the residues required to support and/or orientate the CDR structural loops) and maximum residues (residues which comprise Kabat CDRs, CDR structural loops, residues required to support and/or orientate the CDR structural loops and residues which fall within about 10 Å of a CDR structural loop and possess a water solvent accessible surface of about 5 Å<sup>2</sup> or greater) of the animal monoclonal antibody. Furthermore, computer modeling is performed on all possible recombinant antibodies, comprising the human antibody framework sequence into which minimum and maximum residues have been inserted. The minimum or maximum residues are selected based on the combination which produces a recombinant antibody having a computer-model structure closest to that of the animal monoclonal antibody. The humanized anti-IL-5 antibody obtained appears to have lost a substantial amount of its affinity for the hIL-5 molecule.

It is an aim of the present invention to provide a humanized antibody molecule having improved affinity for the hIL-5 molecule.

Accordingly the present invention provides a RAM having affinity for human IL-5 and comprising antigen binding regions derived from heavy and/or light chain variable domains of a donor antibody having affinity for human IL-5, the RAM having a binding affinity similar to that of the donor antibody.

The RAM of invention may comprise antigen binding regions from any suitable donor anti-IL5 antibody. Typically the donor anti-IL-5 antibody is a rodent MAb. Preferably the donor antibody is MAb 39D10.

The variable domains of the heavy and light chains of MAb 39D10 are hereinafter specifically described with reference to FIGS. 1 and 2.

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According to one preferred aspect of the invention, the RAM of the present invention is an anti-IL-5 antibody molecule having affinity for the human IL-5 antigen comprising a composite heavy chain and a complementary light chain, said composite heavy chain having a variable domain comprising predominantly acceptor antibody heavy chain framework residues and donor antibody heavy chain antigen-binding residues, said donor antibody having affinity for human IL-5, wherein said composite heavy chain comprises donor residues at least at positions 31-35, 50-65 and 95-102 (according to the Kabat numbering system) [Kabat et al., *Sequences of Proteins of Immunological Interest*, Vol I. Fifth Edition, 1991, US Department of Health and Human Services, National Institute of Health].

Preferably, the composite heavy chain framework additionally comprises donor residues at positions 23, 24, 27-30, 37, 49, 73 and 76-78 or 24, 27-30, 37, 49, 73, 76 and 78.

According to a second preferred aspect of the present invention, there is provided an anti-IL-5 antibody molecule having affinity for a human IL-5 antigen comprising a composite light chain and a complementary heavy chain, said composite light chain having a variable domain comprising predominantly acceptor antibody light chain framework residues and donor antibody light chain antigen-binding residues, said donor antibody having affinity for human IL-5, wherein said composite light chain comprises donor residues at least at positions 24-30, 50-56 and 89-97 (according to the Kabat numbering system).

Preferably, the composite light chain framework additionally comprises donor residues at positions 22, 68 and 71 or at positions 68 and 71.

According to a third preferred aspect of the present invention, there is provided an anti-IL-5 antibody molecule having affinity for a human IL-5 antigen comprising a composite heavy chain according to the first aspect of the invention and a composite light chain according to the second aspect of the invention.

Preferably, each RAM of the invention has an affinity constant for human IL-5 of greater than  $10^{-9}$ M.

It will be appreciated that the invention is widely applicable to the production of anti-IL-5 RAMs in general. Thus, the donor antibody may be any anti-IL-5 antibody derived from any animal. The acceptor antibody may be derived from an animal of the same species and may even be of the same antibody class or sub-class. More usually, however, the donor and acceptor antibodies are derived from animals from different species. Typically, the donor anti-IL-5 antibody is a non-human antibody, such as rodent MAb, and the acceptor antibody is a human antibody.

Any appropriate acceptor variable framework sequence may be used having regard to class or type of the donor antibody from which the antigen binding regions are derived. Preferably, the type of acceptor framework used is of the same or similar or type as that of the donor antibody. Conveniently, the framework chosen has the most homology to the donor antibody. Preferably, the human group II gamma germ line frameworks are used for the composite heavy chain and the human group I kappa germ line frameworks are used for the composite light chains.

The constant region domains of the RAMs of the invention may be selected having regard to the proposed functions of the antibody, in particular the effector functions which may be required. For example, the constant regions domains may be human IgA, IgE, IgG or IgM domains. In particular, IgG human constant region domains may be used, especially of the IgG1 and IgG3 isotype, when the humanized antibody molecule is intended for therapeutic uses, and antibody

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effector functions are required. Alternatively, IgG2 and IgG4 isotypes may be used where the humanized antibody molecule is intended for therapeutic purposes and antibody effector functions are not required, e.g. for specifically binding to and neutralizing the biological activity of human IL-5. Modified human constant region domains may also be used in which one or more amino acid residues have been altered or deleted to change a particular effector function. Preferably, the constant region domains of the RAMs are human IgG4.

The residue designations given above and elsewhere in the present application are numbered according to the Kabat numbering [Kabat et al. *Sequences of Proteins of Immunological Interest*, Vol I. Fifth Edition, 1991, US Department of Health and Human Services, National Institute of Health]. Thus, the residue designations do not always correspond directly with a linear numbering of the amino acid residues. The actual linear amino acid sequence may contain fewer or additional amino acids than in the Kabat numbering, corresponding to a shortening of, or insertion into, the basic variable domain structure.

Also the anti-IL-5 antibody molecules of the present invention may have attached to them effector or reporter molecules. Alternatively, the procedure of recombinant DNA technology may be used to produce immunoglobulin molecules in which the Fc fragment or CH3 domain of a complete immunoglobulin has been replaced by, or has been attached thereto by peptide linkage, a functional non-immunoglobulin protein, such as an enzyme, cytokine, growth factor or toxin molecule.

Thus, the remainder of the antibody molecules need not comprise only sequences from immunoglobulins. For instance, a gene may be constructed in which a DNA sequence encoding part of a human immunoglobulin chain is fused to a DNA sequence encoding the amino acid sequence of a polypeptide effector or reporter molecule.

Further aspects of the invention include DNA sequences coding for the composite heavy chain and the composite light chain. The cloning and expression vectors containing the DNA sequences, host cells transformed with the DNA sequences and the processes for producing the antibody molecules comprising expressing the DNA sequences in the transformed host cells are also further aspects of the invention.

The general methods by which vectors may be constructed, transfection methods and culture methods are well known in the art and form no part of the invention.

The DNA sequences which encode the anti-IL-5 donor amino acid sequences may be obtained by methods well known in the art (see, for example, International Patent Application No. WO 93/16184). For example, the anti-IL-5 coding sequences may be obtained by genomic cloning or cDNA cloning from suitable hybridoma cell lines, e.g. the 39D10 cell line. Positive clones may be screened using appropriate probes for the heavy and light chains required. Also PCR cloning may be used.

The DNA coding for acceptor amino acid sequences may be obtained in any appropriate way. For example, DNA sequences coding for preferred human acceptor frameworks such as human group I light chains and human group III heavy chains, are widely available to workers in the art.

The standard techniques of molecules biology may be used to prepare the desired DNA sequences. The sequences may be synthesized completely or in part using oligonucleotide synthesis techniques. Site-directed mutagenesis and polymerase chain reaction (PCR) techniques may be used as appropriate. For example, oligonucleotide directed synthesis

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as described by Jones et al. [Nature, 321, 522 (1986)] may be used. Also oligonucleotide directed mutagenesis of a pre-existing variable regions as, for example, described by Verhoeyen et al. [Science, 239, 1534-1536 (1988)] may be used. Also enzymatic filling in of gapped oligonucleotides using T4 DNA polymerase as, for example, described by Queen et al. [Proc. Natl. Acad. Sci. USA, 86, 10029-10033 (1989) and WO 90/07861] may be used.

Any suitable host cell and vector system may be used for the expression of DNA sequences coding for the RAM. Preferably, eucaryotic, e.g. mammalian, host cell expression systems are used. In particular, suitable mammalian host cells include CHO cells and myeloma or hybridoma cell lines.

Thus, according to a further aspect of the present invention a process for producing an anti-IL-5 RAM is provided comprising:

(a) producing in a first expression vector a first operon having a DNA sequence which encodes a composite heavy chain, as defined according to the first preferred aspect of the invention;

(b) optionally producing in the first or a second expression vector a second operon having a DNA sequence which encodes a complementary light chain, which may be a composite light chain as defined according to the second preferred aspect of the invention;

(c) transfecting a host cell with the or each vector; and

(d) culturing a transfected cell line to produce the RAM.

Alternatively, the process may involve the use of sequences encoding a composite light chain and a complementary heavy chain.

For the production of RAMs comprising both heavy and light chains, the cell lines may be transfected with two vectors. The first vector may contain an operon encoding a composite or complementary heavy chain and the second vector may contain an operon encoding a complementary or composite light chain. Preferably, the vectors are identical except insofar as the coding sequences and selectable markers are concerned so as to ensure as far as possible that each polypeptide chain is equally expressed. In a preferred alternative, a single vector may be used, the vector including the sequences encoding both the heavy chain and the light chain.

The DNA in the coding sequences for the heavy and light chains may comprise cDNA or genomic DNA or both.

The present invention also includes therapeutic and diagnostic compositions comprising the RAMS and uses of such compositions in therapy and diagnosis.

Accordingly, in a further aspect the invention provides a therapeutic or diagnostic composition comprising a RAM according to previous aspects of the invention in combination with a pharmaceutically acceptable excipient, diluent or carrier.

These compositions can be prepared using the RAMs of the present invention, for instance as whole antibodies, single chain Fv fragments or antibody fragments, such as Fab or Fv fragments. Such composition have IL-5 blocking or antagonistic effects and can be used to suppress IL-5 activity.

The compositions according to the invention may be formulated in accordance with conventional practice for administration by any suitable route, and may generally be in a liquid form [e.g. a solution of the RAM in a sterile physiologically acceptable buffer] for administration by for example an intravenous, intraperitoneal or intramuscular route; in spray form, for example for administration by a nasal or buccal route; or in a form suitable for implantation.

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The invention also provides a method of therapy or diagnosis comprising administering an effective amount, preferably 0.1 to 10 mg/kg body weight, of a RAM according to previous aspects of the invention to a human or animal subject. The exact dosage and total dose will vary according to the intended use of the RAM and on the age and condition of the patient to be treated. The RAM may be administered as a single dose, or in a continuous manner over a period of time. Doses may be repeated as appropriate.

The RAM according to previous aspects of the invention may be used for any of the therapeutic uses for which anti-IL-5 antibodies, e.g. 39D10, have been used or may be used in the future.

IL-5 is a primary activator of eosinophils, and blocking the function of this cytokine with antibodies has been shown to prevent or reduce eosinophilia which is associated with certain allergic diseases. Thus the RA according to the invention may be used for this purpose, and in particular may be of use in the treatment of asthma, where it may be expected to prevent the accumulation and activation of eosinophils in asthmatic lungs, thereby reducing bronchial inflammation and airway narrowing. For use in the treatment of asthma the RAM according to the invention may advantageously be a single chain Fv fragment, formulated as a spray, for administration for example via the nasal route.

A preferred protocol for obtaining an anti-IL-5 antibody molecule in accordance with the present invention is set out below. This protocol is given without prejudice to the generality of the invention as hereinbefore described and defined.

The 39D10 rat monoclonal antibody raised against human IL-5 is used as the donor antibody. The variable domains of the heavy and light chains of 39D10 have previously been cloned (WO 93/16184) and the nucleotide and predicted amino acid sequences of these domains are shown in FIGS. 1 and 2. The appropriate acceptor heavy and light chain variable domains must be determined and the amino acid sequence known. The RAM is then designed starting from the basis of the acceptor sequence.

#### 1. The CDRs

At a first step, donor residues are substituted for acceptor residues in the CDRs. For this purpose, the CDRs are preferably defined as follows:

heavy chain:

CDR1: residues 31-35

CDR2: residues 50-65

CDR3: residues 95-102 light chain;

CDR1: residues 24-34

CDR2: residues 50 to 56

CDR3: residues 89 to 97

The positions at which donor residues are to be substituted for acceptor residues in the framework are then chosen as follows, first of all with respect to the heavy chain and subsequently with respect to the light chain.

#### 2. HEAVY CHAIN

2.1. Donor residues are used either at all of positions 24, 27 to 30, 37, 49, 73, 76 and 78 or at all of positions 23, 24, 27 to 30, 37, 49, 73 and 76 to 78 of the heavy chain.

#### 3. LIGHT CHAIN

3.1. Donor residues are used either at all of positions 22, 68 and 71 or at all of positions 68 and 71.

The present invention relates to a recombinant anti-IL-5 antibody molecule having a binding affinity substantially equal to that of the donor antibody. The present invention is now described, by way of example only, with references to the accompanying drawings, in which:

FIG. 1 shows the nucleotide and amino acid sequence of the 39D10 heavy chain;

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FIG. 2 shows the nucleotide and amino acid sequence of the 39D10 light chain;

FIG. 3 shows the alignment of the 39D10 *light*[*heavy*]chain variable domain framework regions with the *light*[*heavy*]chain variable domain framework regions of the consensus sequence of the human group I[II]*light*[*heavy*]chains;

FIG. 4 shows the alignment of the 39D10 *heavy*[*light*]chain variable domain framework regions with the *heavy*[*light*]chain variable domain framework regions of the consensus sequence of the human group III[II]*heavy*[*light*]chains;

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Second Edition, Vols 1 to 3. Cold Spring Harbor Laboratory Press (1989).

### 3. CONSTRUCTION OF RECOMBINANT HEAVY AND LIGHT CHAIN GENES

#### Heavy Chain

A heavy chain V<sub>H</sub> region was generated by PCR using the oligonucleotides R360I and R2155. The sequences of these are:

R3601 5' GCGCGCAAGCTTGGCCACCACATGAAG(A, T)TGTGGTTAAACTGGGTTT3' SEQ ID NO:1

R2155 5' GCAGATGGGCCCTTCGTGAGGCTG(A, C)(A, G)GAGAC(G, T, A) SEQ ID NO:2

FIG. 5 shows the nucleotide and amino acid sequence of the CDR grafted anti-IL-5 light chain CTIL-5-gL6[.]. The first twenty amino acid residues of SEQ ID No: 26 represent a leader sequence. The first amino acid residue of the mature protein is residue 21.

FIG. 6 shows the nucleotide and amino acid sequence of the CDR grafted anti-IL-5 heavy chain CTIL-5-10gH[.]. The first nineteen amino residues SEQ ID No: 28 represent a leader sequence. The first amino acid residue of the mature protein is residue 20.

FIG. 7 shows a map of plasmid pMR14;

FIG. 8 shows a map of plasmid pMR15.1;

FIG. 9 shows the affinity constants and association and dissociation rates of a chimeric 39D10 antibody and the CTIL-5-10gH-gL6 antibody;

FIG. 10 shows a graph of the neutralisation of IL-5 in the TF1 assay by a panel of antibodies;

FIG. 11 shows the results of a competition assay for rat 39D10, a chimeric 39D10 antibody and the CTIL-5-10gH/gL6 antibody; and

FIG. 12 shows the effect of CTIL-5-10gH/gL6 on monkey eosinophilia.

The reaction mixture (100  $\mu$ l) contained 10 mM Tris-HCl pH 8.3, 1.5 mM MgCl<sub>2</sub>, 50 mM KCl, 0.01% w/v gelatin, 0.25 mM of each deoxyribonucleoside triphosphate, 0.1  $\mu$ g 39D10 heavy chain DNA, 6 pmoles of R3601 and R2155 and 0.25 units. Taq polymerase. The reaction mixture was heated at 94° C. for 5 minutes and then cycled through 94° C. for 1 minute, 55° C. for 1 minute and 72° C. for 1 minute. After 30 cycles, the reaction was extracted with an equal volume of phenol/chloroform (1:1 v/v), then with chloroform before being precipitated by the addition of 2.5 volumes of ethanol. The PCR product was dissolved in the appropriate buffer, digested with HindIII and ApaI, purified on an agarose gel and ligated into the vector pMR14 (FIG. 7) which had also been digested with HindIII and ApaI. Following transformation into *E. coli* LM1035, colonies were grown overnight and plasmid DNA analysed for V<sub>H</sub> inserts. The nucleotide sequence of the V<sub>H</sub> region in plasmid, pARH1217, is shown in FIG. 1.

#### Light Chain

A V<sub>L</sub> light chain gene was generated from the original VL as described in WO 93/16184, clone by PCR with the oligonucleotides R3585 and R3597. The sequence of these are:

R3585 5' GGACTGTGTCGAAGCCGCCACCACATGAGTGTGCTCACTCAGGTCTT3' SEQ ID NO:3

R3597 5' GGATACAGTGGTGCCAGCATCCGTACGTTT3' SEQ ID NO:4

## EXAMPLE

### 1. MATERIAL AND METHODS

39D10 is a rat monoclonal antibody raised against human IL-5. The genes for the variable domains of the heavy and light chains of 39D10 have previously been cloned (WO 93/16184) and the nucleotide and predicted amino acid sequences of these domains are shown in FIGS. 1 and 2. Because of the strategy used in the cloning of the variable domain of the 3gD10 heavy chain, the first five amino acids of the framework regions are unknown. However, a heavy chain was available which contained the leader sequence and the first five amino acids of framework 1 from the antibody YTH 34.SHL. Riechmann et al., [Nature, 332, 323-327 (1988)].

### 2. MOLECULAR BIOLOGY PROCEDURES

The molecular biology procedures used were as described in Maniatis et al. [Molecular Cloning: A Laboratory Manual,

PCR was carried out as described above. The PCR product was digested with enzymes BstBI and SphI and, after purification, ligated into pMR15.1 (FIG. 8) that had previously been digested with the same enzymes.

A colony was identified, after transformation of *E. coli* LM1035, that contained a plasmid (pARH1215) with a V<sub>L</sub> insert. The nucleotide sequence of the V<sub>L</sub> insert is shown in FIG. 2.

#### CDR Grafting of 39D10

##### Light Chain

In order to decide on the most appropriate human acceptor frameworks for the CDR loops of 39D10, the main acid sequence of frameworks 1-3 of 39D10 were compared with those of known human kappa light chains, 39D10 was found to be most homologous to human group I light chains. Based on this, it was decided to use the human group I germ line frameworks for the CDR grafting. The homologies between these sequences are shown in FIG. 3. Also shown is the

homology between the framework 4 regions of 39D10 and the consensus sequence of known human group I light chains. The residues in 39D10 that differ from the human consensus sequence are underlined. The contribution that these residues might make to antigen binding was analysed and two genes were constructed for the CDR grafted light chain. These were CTIL-5gL5 and CTIL-5gL6 in which, as well, as the CDR residents, either residues 22, 68 and 71 or residues 68 and 71 were also from 39D10 respectively. The nucleotide and amino acid sequences of CTIL-5-gL6 are shown in FIG. 5.

#### Heavy Chain

CDR grafting of the 39D10 heavy chain was carried out as described for the light chain. The framework regions of 39D10 were found to be most homologous to those of human group III antibodies and, consequently, the consensus sequence of the frameworks of the human group III germ line genes was used to accept the CDRs of the 39D10 heavy chain. As before, the consensus sequence for human group III framework 4 regions was also chosen. A comparison of these sequences is shown in FIG. 4 with the residues in 39D10 that differ from the human consensus sequence underlined.

Analysis of the framework residues in 39D10 that might influence antigen binding was carried out and, based on this, two genes, CTIL-5-9gH and CTIL-5-10gH, were constructed in which either residues 23, 24, 27 to 30, 37, 49, 73 and 76 to 78 or residues 24, 27-30, 37, 49, 73, 76 and 78 respectively were from 39D10. The nucleotide and amino acid sequences of CTIL-5-10gH is shown in FIG. 6.

#### Expression and Bioactivity of Anti-IL-5 Antibodies

Chimeric (rat/human) and CDR grafted 39D10 were produced for biological evaluation by transient expression of the heavy and light chain pairs after co-transfection into Chinese Hamster ovary (CHO) cells using calcium phosphate precipitation.

On the day prior to transfection, semi-confluent flasks of CHO-L761h cells (Cockett et al. Nucl. Acids. Res., 19, 319-325, 1991) were trypsinised, the cells counted and T75 flasks set up each with  $10^7$  cells. On the next day, the culture medium was changed 3 hours before transfection. For transfection, the calcium phosphate precipitate was prepared by mixing 1.25 ml of 0.25 M  $\text{CaCl}_2$  containing 50  $\mu\text{g}$  of each of heavy and light chain expression vectors with 1.25 ml of 2xHBS (16.36 g NaCl, 11.9 gm HEPES and 0.4 g  $\text{Na}_2\text{HPO}_4$  in 1 liter water with the pH adjusted to 7.1 with NaOH) and adding immediately into the medium of the cells. After 3 hours at 37°C. in a  $\text{CO}_2$  incubator, the medium and precipitate were removed and the cells shocked by the addition of 15 ml 15% glycerol in phosphate buffered saline (PBS) for 1 minute. The glycerol was removed, the cells washed once with PBS and incubated for 48-96 hours in 25 ml medium containing 10 KM sodium butyrate. Antibody was purified from the culture medium by binding to and elution from protein A-Sepharose. Antibody concentration was determined using a human Ig ELISA (see below).

#### ELISA

Antibody expression was assessed by transfecting pairs of heavy and light chain genes into CHO cells and, after three days incubation, measuring the amount of antibody accumulating in the culture medium by ELISA.

For the ELISA, Nunc ELISA plates were coated overnight at 4°C. with a  $\text{F}(\text{ab})_2$  fragment of a polyclonal goat anti-human Fc fragment specific antibody (Jackson ImmunoResearch, code 109-006-098) at 5  $\mu\text{g}/\text{ml}$  in coating buffer (15 mM sodium carbonate, 35 mM sodium hydrogen carbonate, pH6.9). Uncoated antibody was removed by

washing 5 times with distilled water. Samples and purified standards to be quantiated were diluted to approximately 1  $\mu\text{g}/\text{ml}$  in conjugate buffer (0.1M Tris-HCl pH7.0, 0.1M NaCl, 0.2% v/v Tween 20, 0.2% w/v Hammersten casein). The samples were titrated in the microtitre wells in 2-fold dilutions to give a final volume of 0.1 in each well and the plates were incubated at room temperature for 1 hour with shaking. After the first incubation step, the plates were washed 10 times with distilled water and then incubated for 1 hour as before with 0.1 ml of a mouse monoclonal anti-human kapps (clone GD12) peroxidase conjugated antibody (The Binding Site, code MP135) at a dilution of 1 in 700 in conjugate buffer. The plate was washed again and substrate solution (0.1 ml) added to each well. Substrate solution contained 150  $\mu\text{l}$  N,N,N,N-tetramethylbenzidine (10 mg/ml in DMSO), 150  $\mu\text{l}$  hydrogen peroxide (30% solution) in 10 ml 0.1M sodium acetate/sodium citrate, pH6.0. The plate was developed for 5-10 minutes until the absorbance at 630 nm was approximately 1.0 for the top standard. Absorbance at 630 nm was measured using a plate reader and the concentration of the sample determined by comparing the titration curves with those of the standard. Determination of Affinity Constants for Anti-IL-5 Antibodies

Affinities of the chimeric and CDR grafted anti-IL-5 antibodies were determined using Biospecific Interaction Analysis (BIA). Antibodies were produced in CHO cells by transfection of combination of heavy and light chain genes and purified from culture supernatants on Protein A Sepharose. For affinity measurements, a polyclonal antihuman Fc antibody was bound to the Pharmacia Biosensor chip (12150 relative response units, RU) and used to capture anti-IL-5 which was passed over the chip at 5  $\mu\text{g}/\text{ml}$  in 10 mM HEPES, 0.15M NaCl, 3.4 mM EDTA, pH7.4. The amount of anti-IL-5 captured for each run was approximately 1600 RU. Recombinant human IL-5 was then passed over the Sensorchip at various concentrations (0.6 to 5  $\mu\text{g}/\text{ml}$ ) in the above buffer. The Sensorchip was cleaned after each run with 100 mM HCl and 100 mM orthophosphoric acid to remove bound IL-5 and antibody. The sensorgrams generated were analysed using the kinetics software available with the BIA-core machine.

Values for the affinity constants and association and dissociation rates of two antibodies, chimeric 39D10 and CTIL-5-10gH-gL6, were determined. The results are shown in FIG. 9. It can be seen that chimeric 39D10 has an extremely high affinity for human IL-5 and that this value has been reproduced in CTIL-5-10gH-gL6.

#### Activity of Anti-IL-5 Antibodies in in vitro Bioassay

The activities of various CDR grafted antibodies were compared with that of chimeric 39D10 in an in vitro bioassay using TF1 cells, TF1 is an erythroleukemic cell line that requires GM-CSF for growth. GM-CSF can be replaced by IL-5 but in this instance the cells only survive and do not proliferate. However the dependence on IL-5 for survival means that TF1 cells can be used in a bioassay to compare the activities of various anti-IL-5 antibodies.

Neutralisation by anti-IL-5 antibodies was measured using a constant amount of IL-5 (2 ng/ml) and variable amounts of antibody incubated with  $5 \times 10^4$  cells per well in 96 flat bottomed plates for 3 days. For the last 4 hours, cells are cultured in the presence of 500  $\mu\text{g}/\text{ml}$  Thiazolyl blue (MTT). This dye is converted into an insoluble purple form by mitochondrial enzymes in viable cells. The insoluble material was dissolved by incubating overnight after addition of 100  $\mu\text{l}$  of 50% dimethyl formamide, 20% SDS pH4.7 and the amount of dye taken up determined spectrophot-

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metrically. The levels of bioactive IL-5 remaining in the presence of the antibodies is extrapolated from a standard curve relating dye uptake to IL-5 concentration.

The activities of various combination of heavy and light chains were evaluated using the TF1 bioassay. The results are shown in FIG. 10. It can be seen that all combinations of CDR grafted heavy and light chains produce antibodies that are equipotent with chimeric 39D10. These results indicate that neither residue 22 in the light chain nor residues 23 or 78 in the heavy chains are required to be 39D10 specific for optimal binding. The combination with the fewer 39D10 specific residues is therefore CTL-5-10gH-gL6.

#### Activity of Anti-IL-5 Antibodies in Competition Assays

Recombinant human IL-5 was diluted to 1 µg/ml in phosphate buffered saline (PBS) and 100 µl aliquots added to microtitre plates (Costar Amine Binding plates) and incubated overnight at 4° C. Plates were washed three times with PBS containing 0.5% Tween 20 and any remaining active sites blocked with 2% bovine serum albumin (BSA) in PBS for 30 minutes. The plates were then aspirated and tapped dry. To compare the relative binding activity of the parent rat antibody (39D10) with chimeric and grafted antibodies, serial dilutions were prepared of each anti-IL-5 antibody in PBS/1% BSA and 50 µl added to duplicate wells followed immediately by 50 µl 39D10-biotin conjugate at 0.125 µg/ml. The assay was incubated for 2 hours at room temperature with agitation and then washed twice with PBS.

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Horseshadish-peroxidase conjugated to streptavidin (1 µg/ml) was added to all wells and incubated for a further 30 minutes. Plates were washed four times and 100 µl tetramethyl benzidine (TMB) substrate added. Colour development was read at 630 nm (reference 490 nm) and OD (630-490) was plotted against log (10) antibody concentration.

When the activities of rat 39D10, chimeric 39D10 and CTL-5-10gH/gL6 were compared in the above competition assay, the results shown in FIG. 11 were obtained. All three antibodies competed equally well with biotinylated-39D10 for binding to IL-5, indicating that the CDR loops of 39D10 had been successfully transferred to the human frameworks.

#### Effect of Anti-IL-5 Antibody on Monkey Eosinophilia

Anti-IL-5 antibody (CTL-5-10gH/gL6) was tested in a monkey system which models asthmatic conditions (see Mauser, P. J. et al., *Am. J. Resp. Crit. Care Med.*, 152:467-472, 1995. When administered, one hour before challenge with *Ascaris*, to responsive monkeys, CTL-5-10gH/gL6 inhibits lung lavage eosinophilia 75% at a dose of 0.3 mg/kg i.v. This set of monkeys is not hyper-responsive to histamine so the effects of CTL-5-10gH/gL6 on hyper-responsiveness could not be determined. Three months after this single dose, eosinophil accumulation in response to *Ascaris* challenge is still inhibited 75%.

In the allergic mouse, CTL-5-10gH/gL6 inhibits pulmonary eosinophilia at 1 mg/kg i.p.

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#### SEQUENCE LISTING

## (1) GENERAL INFORMATION:

(iii) NUMBER OF SEQUENCES: 28

## (2) INFORMATION FOR SEQ ID NO:1:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 47 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: other nucleic acid

(A) DESCRIPTION: /desc = "PCR primer R3601"

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

GCGGCAAGC TTGCCGCCAC CATGAAGTGTG TGGTTAAACT GGGTTTT

47

## (2) INFORMATION FOR SEQ ID NO:2:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 37 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: other nucleic acid

(A) DESCRIPTION: /desc = "PCR primer R2155"

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

CCAGATGGGC CCTTCGTTGA GGCTGMTGAG ACDGTGA

37

## (2) INFORMATION FOR SEQ ID NO:3:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 44 base pairs
- (B) TYPE: nucleic acid

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(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: other nucleic acid  
(A) DESCRIPTION: /desc = "PCR primer R3585"

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

GGACTGTTCG AAGCCGCCAC CATGAGTGTG CTCACTCAGG TCCT 44

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 30 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: other nucleic acid  
(A) DESCRIPTION: /desc = "PCR primer R3597"

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

GGATACAGTT GGTGCAGCAT CGTACGTTT 30

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 333 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

GAATCTGGAG GAGCCTGGT ACAGCCATCA CAGACCCCTGT CTCACCCCTG CACTGTCTCT 60  
GGTTATCAT TAACCAGCAA TAGTGTGAAC TGGATTGGC AGCCTCCAGG AAAGGGTCTG 120  
GAGTGGATGG GACTAATATG GAGTAATGA GACACAGATT ATAATTCAGC TATCAAATCC 180  
CGACTGAGCA TCAGTAGGGA CACCTCGAAG AGCCAGGTTT TCTTAAAGAT GAACAGTCTG 240  
CAAAGTGAAG ACACAGCCAT GTACTTCTGT GCCAGAGAGT ACTACGGCTA CTTTGATTC 300  
TGGGGCCAAG GAGTCATGGT CACAGTCTCC TCA 333

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 111 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

Glu Ser Gly Gly Gly Leu Val Gln Pro Ser Gln Thr Leu Ser Leu Thr  
1 5 10 15  
Cys Thr Val Ser Gly Leu Ser Leu Thr Ser Asn Ser Val Asn Trp Ile  
20 25 30  
Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Met Gly Leu Ile Trp Ser  
35 40 45  
Asn Gly Asp Thr Asp Tyr Asn Ser Ala Ile Lys Ser Arg Leu Ser Ile  
50 55 60  
Ser Arg Asp Thr Ser Lys Ser Gln Val Phe Leu Lys Met Asn Ser Leu  
65 70 75 80

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Gln Ser Glu Asp Thr Ala Met Tyr Phe Cys Ala Arg Glu Tyr Tyr Gly  
                   85                  90                  95  
 Tyr Phe Asp Tyr Trp Gly Gln Gly Val Met Val Thr Val Ser Ser  
           100                  105                  110

## (2) INFORMATION FOR SEQ ID NO:7:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 384 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

ATGGCTGTGC CCACTCAGCT CCTGGGGTTC TTGTGTCTGT GGATTACAGA TGCCATATGT 60  
 GACATCCAGA TGACACAGTC TCCAGCTTCC CTGTCTGCAT CTCTGGGAGA AACTATCTCC 120  
 ATCGAATGTC TAGCAAGTGA GGCATTTCC AGTATTTTAC CGTGGTATCA GCAGAAGCCA 180  
 GGGAAATCTC CTCAGCTCCT GATCTATGGT GCAAATAGCT TGCAAAGTGG GGTCCCATCA 240  
 CGGTTCAAGT GCAGTGGATC TGCCACACAA TATTCTCTCA AGATCAGCAG CATGCCAACCT 300  
 GAAGATGAAG GGGATTATTT CTGTCAACAG AGTTACAAGT TTCCGAACAC GTTTGGAGCT 360  
 GGGACCAAGC TGGAACTGAA ACCG 384

## (2) INFORMATION FOR SEQ ID NO:8:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 128 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

Met Ala Val Pro Thr Gln Leu Leu Gly Leu Leu Leu Leu Trp Ile Thr  
 1                  5                  10                  15  
 Asp Ala Ile Cys Asp Ile Gln Met Thr Gln Ser Pro Ala Ser Leu Ser  
           20                  25                  30  
 Ala Ser Leu Gly Glu Thr Ile Ser Ile Gly Cys Leu Ala Ser Glu Gly  
           35                  40                  45  
 Ile Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ser Pro  
           50                  55                  60  
 Gln Leu Leu Ile Tyr Gly Ala Asn Ser Leu Gln Thr Gly Val Pro Ser  
           65                  70                  75                  80  
 Arg Phe Ser Gly Ser Gly Ser Ala Thr Gln Tyr Ser Leu Lys Ile Ser  
           85                  90                  95  
 Ser Met Gln Pro Glu Asp Glu Gly Asp Tyr Phe Cys Gln Gln Ser Tyr  
           100                  105                  110  
 Lys Phe Pro Asn Thr Phe Gly Ala Gly Thr Lys Leu Glu Leu Lys Arg  
           115                  120                  125

## (2) INFORMATION FOR SEQ ID NO:9:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 23 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

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(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser Ala Ser Val Gly  
 1 5 10 15

Asp Arg Val Thr Ile Thr Cys  
 20

(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 23 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

Asp Ile Gln Met Thr Gln Ser Pro Ala Ser Leu Ser Ala Ser Leu Gly  
 1 5 10 15

Glu Thr Ile Ser Ile Glu Cys  
 20

(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 15 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr  
 1 5 10 15

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 15 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

Trp Tyr Gln Gln Lys Pro Gly Lys Ser Pro Gln Leu Leu Ile Tyr  
 1 5 10 15

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 32 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr  
 1 5 10 15

Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys  
 20 25 30

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## (2) INFORMATION FOR SEQ ID NO:14:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 32 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser Ala Thr Gln Tyr Ser  
 1                   5                   10                   15

Leu Lys Ile Ser Ser Met.Gln Pro Glu Asp Glu Gly Asp Tyr Phe Cys  
 20                   25                   30

## (2) INFORMATION FOR SEQ ID NO:15:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 11 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

Phe Gly Gln Gly Thr Lys Val Glu Ile Lys Arg  
 1                   5                   10

## (2) INFORMATION FOR SEQ ID NO:16:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 11 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

Phe Gly Ala Gly Thr Lys Leu Glu Leu Lys Arg  
 1                   5                   10

## (2) INFORMATION FOR SEQ ID NO:17:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 30 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln Pro Gly Gly  
 1                   5                   10                   15

Ser Leu Arg Leu Ser Cys Ala Ala Ser Gly Phe Thr Phe Ser  
 20                   25                   30

## (2) INFORMATION FOR SEQ ID NO:18:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 30 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

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(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Xaa Xaa Xaa Xaa Xaa Glu Ser Gly Gly Gly Leu Val Gln Pro Ser Gln  
 1                   5                   10                   15  
 Thr Leu Ser Leu Thr Cys Thr Val Ser Gly Leu Ser Leu Thr  
           20                   25                   30

(2) INFORMATION FOR SEQ ID NO:19:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 14 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Trp Val Arg Gln Ala Pro Gly Lys Gly Leu Glu Trp Val Ser  
 1                   5                   10

(2) INFORMATION FOR SEQ ID NO:20:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 14 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

Trp Ile Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Met Gly  
 1                   5                   10

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 32 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Arg Phe Thr Ile Ser Arg Asp Asn Ser Lys Asn Thr Leu Tyr Leu Gln  
 1                   5                   10                   15  
 Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr Tyr Cys Ala Arg  
           20                   25                   30

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 32 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

Arg Leu Ser Ile Ser Arg Asp Thr Ser Lys Ser Gln Val Phe Leu Lys  
 1                   5                   10                   15  
 Met Asn Ser Leu Gln Ser Glu Asp Thr Ala Met Tyr Phe Cys Ala Arg

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(2) INFORMATION FOR SEQ ID NO:23:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 11 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser  
 1           5                   10

(2) INFORMATION FOR SEQ ID NO:24:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 11 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

Trp Gly Gln Gly Val Met Val Thr Val Ser Ser  
 1           5                   10

(2) INFORMATION FOR SEQ ID NO:25:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 399 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

```

TTCGAAGCCG CCAACATGTC TGTCGCCACC CAAGTCTCG GTCTCCTGCT GCTGTGGCTT    60
ACAGATGCCA GATGTGACAT TCAAATGACC CAGAGCCCAT CCAGCCTGAG CGCATCTGTA    120
GGAGACCGGG TCACCATCAC ATGTCTAGCA AGTGAGGCCA TCTCCAGTTA CTTAGCCGTG    180
TACCAGCAGA AGCCCGGAA AGCTCCTAAG CTCTGATCT ATGGTCCGAA TAGCTTGCG    240
ACTGGAGTAC CATCAAGATT CAGTGGCTCA GGATCCGCTA CAGACTACAC GCTCAGGATC    300
TCCAGCCTAC AGCCTGAAGA TTTCGCAACG TATTACTGTC AACAGTCGTA TAAGTCCCG    360
AACACATTCG GTCAAGGCAC CAAGTCCGAA GTCAAACGT    399
    
```

(2) INFORMATION FOR SEQ ID NO:26:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 128 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

Met Ser Val Pro Thr Gln Val Leu Gly Leu Leu Leu Leu Trp Leu Thr  
 1           5                   10                   15  
 Asp Ala Arg Cys Asp Ile Gln Met Thr Gln Ser Pro Ser Ser Leu Ser  
           20                   25                   30

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Ala Ser Val Gly Asp Arg Val Thr Ile Thr Cys Leu Ala Ser Glu Gly  
 35 40 45  
 Ile Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro  
 50 55 60  
 Lys Leu Leu Ile Tyr Gly Ala Asn Ser Leu Gln Thr Gly Val Pro Ser  
 65 70 75 80  
 Arg Phe Ser Gly Ser Gly Ser Ala Thr Asp Tyr Thr Leu Thr Ile Ser  
 85 90 95  
 Ser Leu Gln Pro Glu Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Ser Tyr  
 100 105 110  
 Lys Phe Pro Asn Thr Phe Gly Gln Gly Thr Lys Val Glu Val Lys Arg  
 115 120 125

## (2) INFORMATION FOR SEQ ID NO:27:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 420 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

AAGCTTGCCG CCACCATGGG CTGGAGCTGT ATCATCTCTT TCTTAGTAGC AACAGCTACA 60  
 GGTGTCCACT CCGAGGTCCA ACTGGTAGAA TCTGGAGGTG GTCTCGTACA GCCAGGAGGA 120  
 TCTCTGGGAC TGAGTTGCGC CGTCTCTGGG TTATCATTAA CTAGTAATAG TGGAACCTGG 180  
 ATACGGCAAG CACCTGGCAA GGGTCTCGAG TGGTTGGAC TAATATGGAG TAATGGAGAC 240  
 ACAGATTATA ATTCACTAT CAAATCTCGA TTCACAATCT CTAGAGACAC TTCGAAGAGC 300  
 ACCGTATACC TGCAGATGAA CAGTCTGAGA GCTGAAGATA CTGCAGICTA CTACTGTGCT 360  
 CGTGAGTACT ATGGATATTT CGACTATTGG GGTC AAGGTA CCTAGTCCAC AGTCTCTCA 420

## (2) INFORMATION FOR SEQ ID NO:28:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 135 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

Met Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly  
 1 5 10 15  
 Val His Ser Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln  
 20 25 30  
 Pro Gly Gly Ser Leu Arg Leu Ser Cys Ala Val Ser Gly Leu Ser Leu  
 35 40 45  
 Thr Ser Asn Ser Val Asn Trp Ile Arg Gln Ala Pro Gly Lys Gly Leu  
 50 55 60  
 Glu Trp Val Gly Leu Ile Trp Ser Asn Gly Asp Thr Asp Tyr Asn Ser  
 65 70 75 80  
 Ala Ile Lys Ser Arg Phe Thr Ile Ser Arg Asp Thr Ser Lys Ser Thr  
 85 90 95  
 Val Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp Thr Ala Val Tyr  
 100 105 110

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-continued

Tyr Cys Ala Arg Glu Tyr Tyr Gly Tyr Phe Asp Tyr Trp Gly Gln Gly  
 115 120 125

Thr Leu Val Thr Val Ser Ser  
 130 135

We claim:

1. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen comprising a composite heavy chain and a composite light chain, said composite heavy chain and light chain forming a variable domain comprising acceptor antibody framework residues, said variable domain comprising corresponding donor residues from murine monoclonal 39D10 heavy chain variable region consisting of the sequence of SEQ ID No:6 at residues 31-35, 50-65 and 95-102 and at framework residues 23, 24, 27-30, 37, 49, 73, 76, 77, and 78, and corresponding donor residues from murine monoclonal antibody 39D10 light chain variable region consisting of the sequence of SEQ ID No:8 at residues 24-34, 50-56 and 89-97 and at framework residues 22, 68, and 71 according to the Kabat numbering system.

2. An antibody molecule according to claim 1 wherein the acceptor antibody framework residues for the composite heavy chain are human group III heavy chain residues, and the acceptor antibody framework residues for the composite light chain are human group I light chain residues.

3. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen, comprising [the] a heavy chain variable region amino acid sequence comprising residues 20-135 of SEQ ID No: 28 and [the] a light chain variable region amino acid sequence comprising residues 21-128 of SEQ ID No: 26.

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4. A composition comprising the antibody molecule of any one of claims 1, 2, or 3 in combination with a pharmaceutically acceptable carrier, diluent or excipient.

5. A recombinant antibody molecule that specifically binds human interleukin-5 antigen comprising a composite heavy chain and a composite light chain, said composite heavy chain and light chain forming a variable domain comprising acceptor antibody framework residues, said variable domain comprising corresponding donor residues from murine monoclonal antibody 39D10 heavy chain variable region consisting of the sequence of SEQ ID NO:6 at residues 31-35, 50-65 and 95-102 and at framework residues 24, 27-30, 37, 49, 73, 76 and 78, and corresponding donor residues from murine monoclonal antibody 39D10 light chain variable region consisting of the sequence of SEQ ID No:8 at residues 24-34, 50-56 and 89-97 and at framework residues 68 and 71 according to the Kabat number system.

6. A recombinant antibody molecule that specifically binds human Interleukin-5 antigen, comprising a heavy chain variable region encoded by SEQ ID No: 27 and a light chain variable region encoded by SEQ ID No:25.

7. A composition comprising the antibody molecule of any one of claims 5 or 6 in combination with a pharmaceutically acceptable carrier, diluent, or excipient.

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