

Animal models and therapeutic molecules

Background

The present invention relates inter alia to non-human animals and cells that are engineered to contain exogenous DNA, such as human immunoglobulin gene DNA, their use in medicine and the study of disease, methods for production of non-human animals and cells, and antibodies and antibody chains produced by such animals and derivatives thereof.

Summary of the Invention

All nucleotide co-ordinates for the mouse are those corresponding to NCBI m37 for the mouse C57BL/6J strain, e.g. April 2007 ENSEMBL Release 55.37h, e.g. NCBI37 July 2007 (NCBI build 37) (e.g. UCSC version mm9 see [World Wide Web \(www\) genome.ucsc.edu](http://www.genome.ucsc.edu) and [World Wide Web \(www\) genome.ucsc.edu/FAQ/FAQreleases.html](http://www.genome.ucsc.edu/FAQ/FAQreleases.html)) unless otherwise specified. Human nucleotides coordinates are those corresponding to GRCh37 (e.g. UCSC version hg 19, [World Wide Web \(www\) genome.ucsc.edu/FAQ/FAQreleases.html](http://www.genome.ucsc.edu/FAQ/FAQreleases.html)), Feb 2009 ENSEMBL Release 55.37, or are those corresponding to NCBI36, Ensemble release 54 unless otherwise specified. Rat nucleotides are those corresponding to RGSC 3.4 Dec 2004 ENSEMBL release 55.34w, or Baylor College of Medicine HGSC v3.4 Nov 2004 (e.g., UCSC m4, see [World Wide Web \(www\) genome.ucsc.edu](http://www.genome.ucsc.edu) and [World Wide Web \(www\) genome.ucsc.edu/FAQ/FAQreleases.html](http://www.genome.ucsc.edu/FAQ/FAQreleases.html)) unless otherwise specified. Reference to work in mice herein is by way of example only, and reference to mice is taken to include reference to all non-human mammals unless otherwise apparent from the disclosure, with mice being preferred as the non-human mammal.

The disclosures of US2012/0204278 and PCT/GB2013/050682 are incorporated herein by reference. All definitions disclosed in US2012/0204278 and PCT/GB2013/050682 are specifically and explicitly disclosed herein.

Reference to human gene segments herein encompasses both the germline human gene segment sequence or the recombined form of the gene segment that can include one or more mutations relative to the germline human gene segment sequence, for example alleles disclosed in the IMGT database and 1000 Genomes database, as well as in WO2013041844 (such alleles and their sequences being explicitly incorporated herein by reference).

All gene segments referred to herein can be identified using standard sequence analysis by comparison to human germline gene segment sequences optionally by reference to the public sequence databases, such as the IMGT or 1000 Genomes database.

5 In one aspect the invention relates to a non-human vertebrate (e.g., a mouse or rat) or cell whose genome comprises human VH, D and JH gene segments upstream of a constant region at a heavy chain locus and/or human VL and JL gene segments upstream of a constant region at a light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin heavy and/or light chains comprising human VH and VL
10 domains respectively, wherein the heavy chain locus comprises a human 01 allele VH gene segment capable of recombining with a human D and JH gene segment to produce a VH domain, wherein the light chain locus comprises a human 01 allele VL gene segment capable of recombining with a human JL gene segment to produce a VL domain, or wherein the cell can develop into a vertebrate that expresses said heavy
15 and/or light chains.

As explained further in the examples below, the inventors have surprisingly shown that human 01 alleles can be used to produce antigen-specific binding sites, wherein these are properly recombined in a non-human vertebrate, display junctional and somatic mutations and can be properly expressed and isolated.

20 In another aspect the invention relates to a non-human vertebrate or cell (eg, a mouse cell or rat cell) whose genome comprises (a) human JH2*01 and/or human JH6*01 or JH6*02 and/or JH3*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain locus and/or (b) human Jk2*01 and/or human Jk4*01 and one or more human Vk gene segments
25 upstream of a constant region at a light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate or cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein the heavy chain is produced by recombination of the
30 human JH2*01 and/or JH6*01 or JH6*02 segment and/or JH3*02 with a D segment and a VH segment and the light chain is produced by recombination of the human Jk2*01 and/or Jk4*01 segment with a Vk segment. In an example, the genome comprises human JH2*01. In an example, the genome comprises human JH2*01 and JH6*01. In an example, the genome comprises human JH2*01, JH6*01 and JH3*02. In an
35 example, the genome comprises human JH6*01. In an example, the genome comprises

human JH6*01 and JH3*02. In an example, the genome comprises human JH3*02. In an example, the heavy chain is produced by recombination of the human JH2*01 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH6*01 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH6*02 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH3*02 segment with a D segment and a VH segment.

In another aspect the invention relates to a non-human vertebrate whose genome comprises (i) human JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and/or JH6*01 or JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain locus and/or (ii) human Jk1*01, Jk2*01, Jk3*01, Jk4*01 and/or Jk5*01 and one or more human Vk gene segments upstream of a constant region at a light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate or cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and/or an antibody light chain, wherein the heavy chain is produced by recombination of the human JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and/or JH6*01 or JH6*02 segment with a D segment and a VH segment and the light chain is produced by recombination of the human Jk1*01, Jk2*01, Jk3*01, Jk4*01 and/or Jk5*01 segment with a Vk segment. In an example, the genome comprises human JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and JH6*01. In an example, the genome comprises human JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and JH6*02. In an example, the heavy chain is produced by recombination of the human JH2*01 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH6*01 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH6*02 segment with a D segment and a VH segment. In an example, the heavy chain is produced by recombination of the human JH3*02 segment with a D segment and a VH segment. Additionally or alternatively to these heavy chain examples, in an example the light chain is produced by recombination of the human Jk2*01 segment with a Vk segment.

In one embodiment, the non-human vertebrate further comprises one or more of the VH gene segments and/or one or more of the D gene segments from Table 7 and/or one or more Vk gene segments from Table 12. In a further embodiment, the non-human

vertebrate further comprises the VH gene segments and D gene segments from Table 3 and/or the Vk gene segments from Table 10 or 11.

The segments described herein have been identified by the inventors as being widely and highly used across diverse human ethnic populations, and thus widely tolerated for antibody generation and efficacy in humans in general.

In a further embodiment, the invention relates to a non-human vertebrate or vertebrate cell (e.g. a mouse cell or rat cell) whose genome comprises one or more human VH gene segments, one or more human JH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain locus and one or more human JL gene segments and one or more human VL gene segments upstream of a constant region at a light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate or cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein said one or more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01, VH3-20*d01 and VH3-9*01.

In a further embodiment, the invention relates to a non-human vertebrate or vertebrate cell (e.g. a mouse cell or rat cell) whose genome comprises one or more human VH gene segments, one or more human JH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain locus and one or more human Jk gene segments and one or more human Vk gene segments upstream of a constant region at a light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate or cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein said one or more human Vk gene segments comprise or consist of one, more or all human Vk gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

In another embodiment the invention relates to a non-human vertebrate or vertebrate cell (eg, a mouse cell or rat cell) whose genome comprises human JH2*01 and/or

human JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain locus and/or human Jk2*01 and/or human Jk4*01 and one or more human Vk gene segments upstream of a constant region at a light chain locus, wherein the gene segments in each locus are
5 operably linked to the constant region thereof so that the cell or vertebrate is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein the heavy chain is produced by recombination of the human JH2*01 and/or JH6*02 segment with a D segment and a VH segment and/or the light chain is
10 produced by recombination of the human Jk2*01 and/or Jk4*01 segment with a Vk segment;

wherein said one or more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and
15 VH3-20*d01 and/or

wherein said one or more human Vk gene segments comprise or consist of one, more or all human VH gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

20 Optionally reference to a human gene segment herein is the recombined form of the gene segment.

As explained further in the examples below, the inventors have surprisingly shown that heavy and/or light chains produced according to the invention can be used to produce antigen-specific binding sites, wherein these are properly recombined in a non-human
25 vertebrate, display junctional and somatic mutations and can be properly expressed and isolated.

In another aspect the invention relates to a non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises an Ig gene segment repertoire produced by targeted
30 insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments are selected from one, more or all of the segments of Table 18 and have been provided by insertion into an endogenous light chain locus of the vertebrate or cell, wherein the vertebrate comprises immunoglobulin light chains

comprising lambda variable regions (lambda light chains) or the cell can develop into a vertebrate that expresses said immunoglobulin light chains, wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable regions recombinants of one, more or all of the human V λ and J λ gene segments of Table 18.

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Endogenous Light Chain Inactivation & High Expression of Human Lambda Variable Regions in Transgenic Non-Human Vertebrates & Cells

As explained further in the examples below, the inventors have surprisingly observed
10 very high expression levels of light chains comprising human lambda variable regions (at least 70 or 80% human V lambda) from transgenic light chain loci produced by targeted insertion of human lambda gene segments into endogenous non-human vertebrate light chain loci. This is possible even in the presence of endogenous non-human vertebrate V and J gene segments in the vertebrate genome. Also, the surprisingly high levels of
15 expression are achieved when insertion of human lambda gene segments are in the endogenous kappa or lambda locus. Such high levels by targeted insertion has not hitherto been published in the art.

The inventors also surprisingly observed that endogenous kappa chain expression can be completely inactivated by targeted insertion of human lambda gene sequence into the
20 endogenous kappa locus, as explained further in the examples.

The targeted insertion of human gene segments into endogenous Ig loci is advantageous because it enables the operable location of inserted human Ig sequences with respect to endogenous Ig constant regions and endogenous control regions, such as enhancers and other locus control regions for example. Thus, targeted insertion
25 allows one to harness endogenous control important in one or more of Ig gene segment recombination, allelic exclusion, affinity maturation, class switching, levels of Ig expression and desirable development of the B-cell compartment. As such, targeted insertion is superior to early attempts in the art to produce transgenic Ig loci and expression, which attempts relied on the introduction into non-human vertebrate cells of
30 vectors such as YACs bearing human Ig gene segments. YACs are randomly integrated into the vertebrate cell genome, so that it is difficult to achieve the control provided by targeted insertion and the concomitant benefits that are brought in terms of harnessing endogenous control mechanisms. In addition, random insertion often results in the inserted human Ig gene segments coming under the control of heterologous control
35 elements and/or epigenetic chromosomal modifications such as methylation and chromatin conformations, either of which can be detrimental to proper Ig gene segment

recombination, allelic exclusion, affinity maturation, class switching, levels of Ig expression and desirable development of the B-cell compartment. Random insertion typically results in 2 or more copies of the introduced transgene which can cause chromosomal instability and therefore result in poor breeding performance of the animals

5 in addition to detrimental effects on proper Ig gene segment recombination, allelic exclusion, affinity maturation, class switching, levels of Ig expression and desirable development of the B-cell compartment. Thus, prior art attempts using random insertion have tended to lead to poor B-cell development, relatively small B-cell compartments and inferior Ig expression and a concomitant difficulty in isolating an antibody with a

10 desired characteristic.

The invention therefore provides the following aspects:-

Expression of human lambda variable regions

Every embodiment of the invention disclosed herein can be put into practice with a specific lambda allele disclosed in Table 18, or any combination thereof. Where gene

15 segments are referred to herein without reference to a specific allele, these can optionally be the specific alleles disclosed in any one of Tables 1 to 18.

1. A non-human vertebrate (eg, a mouse or rat) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments

20 upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate, wherein the vertebrate expresses immunoglobulin light chains comprising lambda variable regions (lambda light chains), wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable regions derived from recombination of human V λ and

25 J λ gene segments.

A non-human vertebrate (eg, a mouse or rat) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments

30 upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate, wherein the vertebrate expresses immunoglobulin light chains comprising lambda variable regions (lambda light chains), and wherein at least 70 or 80% of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of

human V λ and J λ gene segments. This is demonstrated in the examples below.

For example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99%, or 100% of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human V λ and J λ gene segments. This is demonstrated in the examples below.

In embodiments, there is provided

10 A non-human vertebrate ES cell (eg, a mouse ES cell or rat ES cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate cell, wherein the cell can develop into a vertebrate that expresses immunoglobulin light chains comprising lambda variable regions (lambda light chains), wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable regions derived from recombination of human V λ and J λ gene segments.

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A non-human vertebrate ES cell (eg, a mouse ES cell or rat ES cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate cell, wherein the cell can develop into a vertebrate that expresses immunoglobulin light chains comprising lambda variable regions (lambda light chains), and wherein at least 70 or 80% (for example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99%, or 100%) of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human V λ and J λ gene segments.

In an example, surprisingly expression of immunoglobulin light chains comprising lambda variable regions derived from recombination of human V λ and J λ gene segments is achieved even when the genome comprises endogenous non-human vertebrate lambda variable region gene segments (eg, endogenous V λ and/or J λ gene segments, optionally a complete endogenous repertoire of V λ and J λ gene segments). Thus, in an example, the genome comprises endogenous non-human vertebrate lambda variable

region gene segments (eg, endogenous V λ and/or J λ gene segments, optionally a complete endogenous repertoire of V λ and J λ gene segments). In another example, such endogenous gene segments are absent from the genome.

52. The vertebrate or cell of aspect 1, optionally wherein the human V λ and J λ insertion comprises at least the functional human V and J gene segments (optionally also human C λ) comprised by a human lambda chain Ig locus from V λ 2-18 to C λ 7. In one example, the insertion also comprises lambda inter-gene segment sequences. These are human sequences or they can be sequences of the non-human vertebrate species (eg, where
- 10 the vertebrate is a mouse, sequences between corresponding mouse lambda gene segments can be used).

In one embodiment, the V and J gene segments are the alleles of Table 18. In a further embodiment, the C λ gene segments are the alleles disclosed in Table 18.

153. The vertebrate or cell of aspect 1 or 2, optionally wherein the genome is homozygous for the human V λ and J λ gene segment insertion and endogenous kappa chain expression in said vertebrate is substantially or completely inactive. In one example, less than 10, 5, 4, 3, 2, 1 or 0.5% of light chains are provided by endogenous kappa chains (ie, kappa chains whose variable regions are derived from recombination of non-human vertebrate
- 20 V and J gene segments).

4. The vertebrate or cell of any preceding aspect, optionally wherein the endogenous locus is an endogenous kappa locus.

255. The vertebrate or cell of any preceding aspect, optionally wherein the endogenous locus is an endogenous lambda locus.

$\geq 60\%$ of all light chains have human lambda V regions

6. A non-human vertebrate (eg, a mouse or rat) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising (i) human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments
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have been provided by insertion into an endogenous light chain locus of the vertebrate and (ii) kappa V gene segments upstream of a constant region, wherein the vertebrate expresses immunoglobulin light chains comprising human lambda variable regions (human lambda light chains), and wherein at least 60% of the light chains expressed by the vertebrate are provided by said human lambda light chains. This is demonstrated in the examples below.

For example, at least 65, 70, 80, 84, 85, 90, 95, 96, 97, 98 or 99%, or 100% of the light chains expressed by the vertebrate are provided by said human lambda light chains.

For example, at least 84% of the light chains expressed by the vertebrate are provided by said human lambda light chains. For example, at least 95% of the light chains expressed by the vertebrate are provided by said human lambda light chains. This is demonstrated in the examples below.

In one embodiment, there is provided a non-human vertebrate ES cell (eg, a mouse ES cell or rat ES cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising (i) human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate and (ii) kappa V gene segments upstream of a constant region, wherein the cell can develop into a vertebrate that expresses immunoglobulin light chains comprising human lambda variable regions (human lambda light chains), and wherein at least 60% of the light chains expressed by the vertebrate are provided by said human lambda light chains.

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7. A non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising a targeted insertion of human immunoglobulin V λ and J λ gene segments into an endogenous non-human vertebrate light kappa or lambda chain locus downstream of endogenous VL and JL gene segments for expression of light chains comprising human lambda variable regions; wherein the human V λ and J λ insertion comprises at least the functional human V and J (and optionally also functional human C λ) gene segments comprised by a human lambda chain Ig locus from V λ 2-18 to C λ 7.

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As demonstrated in the examples, endogenous light chain expression from said locus is

inactivated and also human lambda variable region expression dominates over endogenous lambda variable region expression.

By “downstream” is meant 3’ of the gene segments on the same chromosome. In one example, the endogenous V and J gene segments are inverted with respect to the human gene segments and optionally moved out of the endogenous light chain locus. In one example, the human gene segments are downstream of all of the endogenous V and J segments of said kappa or lambda locus. The possibility of retaining the endogenous V-J sequences and intergenic sequences is advantageous since embedded control regions and/or genes are retained that may be desirable in the vertebrate.

Optionally the insertion also comprises lambda inter-gene segment sequences. These are human sequences or they can be sequences of the non-human vertebrate species (eg, where the vertebrate is a mouse, sequences between corresponding mouse lambda gene segments can be used).

Expression of VJCLambda Chains

8. A non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising a targeted insertion of human immunoglobulin V λ , J λ and C λ genes into an endogenous non-human vertebrate kappa or lambda light chain locus upstream of an endogenous non-human vertebrate kappa or lambda constant region for expression of a human VJC light chain; optionally wherein the human VJC insertion comprises at least the functional human V, J and C gene segments comprised by a human lambda chain Ig locus from V λ 3-1 to C λ 7 (eg, comprised by a human lambda chain Ig locus from 2-18 to C λ 7).

In one embodiment, the V and J gene segments are the alleles of Table 18. In a further embodiment, the C λ gene segments are the alleles disclosed in Table 18.

As demonstrated in the examples, human lambda variable region expression dominates over endogenous kappa variable region expression. Endogenous kappa chain expression from the endogenous locus can be inactivated.

Optionally the insertion also comprises lambda inter-gene segment sequences. These are human sequences or they can be sequences of the non-human vertebrate species (eg, where the vertebrate is a mouse, sequences between corresponding mouse lambda gene segments can be used).

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9. A non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising a targeted insertion of at least the functional human V λ and J λ (and optionally human functional C λ) gene segments comprised by a human lambda chain Ig locus from V λ 3-1 to C λ 7 (optionally from V λ 2-18 to C λ 7, further optionally the specific alleles of Table 18) into an endogenous non-human vertebrate kappa light chain locus downstream of the mouse V κ and J κ gene segments for expression of a light chain comprising a human lambda variable region, whereby in the presence of said insertion expression of endogenous kappa light chains derived from said mouse V κ and J κ gene segments is substantially or completely inactivated.

In one example, less than 10, 5, 4, 3, 2, 1 or 0.5% of light chains are provided by endogenous kappa chains (ie, kappa chains whose variable regions are derived from recombination of non-human vertebrate V κ and J κ gene segments).

Optionally the insertion also comprises lambda inter-gene segment sequences. These are human sequences or they can be sequences of the non-human vertebrate species (eg, where the vertebrate is a mouse, sequences between corresponding mouse lambda gene segments can be used).

10. A non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell), wherein in the genome of which the mouse IgK-VJ has been moved away from the mouse E κ enhancer, thereby inactivating endogenous IgK-VJ regions. This is demonstrated in the examples.

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11. The vertebrate of cell of aspect 10, optionally wherein the IgK-VJ has been moved away from the mouse E κ enhancer by insertion of human V λ and J λ gene segments between the mouse IgK-VJ and the E κ enhancer; optionally wherein the insertion is an insertion as recited in any preceding aspect 1-9 or an insertion of human V κ and J κ gene

segments.

12. The vertebrate or cell of any preceding aspect, optionally wherein the human V λ and J λ gene segments have been inserted within 100, 75, 50, 40, 30, 20, 15, 10 or 5kb of an endogenous non-human vertebrate light chain enhancer. In one example, the enhancer is a lambda enhancer (eg, mouse E λ 2-4, E λ 4-10 or E λ 3-1) when the insertion is into an endogenous lambda locus. In one example, the enhancer is a kappa enhancer (eg, iE κ or 3'E κ) when the insertion is into an endogenous kappa locus.
1013. The vertebrate or cell of any preceding aspect, optionally wherein the human V λ and J λ gene segments are provided in the genome by the targeted insertion of at least 10 human V λ gene segments with human J λ gene segments upstream of an endogenous non-human vertebrate light chain constant region of said light chain locus. For example, the human gene segments are provided by insertion of at least a portion of a human Ig lambda chain locus from V λ 2-18 to V λ 3-1; or at least a portion of a human Ig lambda chain locus from V λ 2-18 to V λ 3-1 inserted with J λ 1, J λ 2, J λ 3, J λ 6 and J λ 7; or at least a portion of a human Ig lambda chain locus from V λ 2-18 to C λ 7 (optionally excluding J λ 4C λ 4 and/or J λ 5C λ 5).
- 20 Optionally at least 2, 3, 4 or 5 human J λ are inserted. In one embodiment, the inserted J λ s are different from each other. For example, human J λ 1, J λ 2, J λ 3, J λ 6 and J λ 7 are inserted, optionally as part of respective human J λ C λ clusters.
- Optionally a human light chain enhancer, eg E λ , is inserted. For example, insertion of human E λ between the human J λ segments and the endogenous constant region; or between human C λ gene segments (when these are inserted) and the endogenous constant region.
14. The vertebrate or cell of any preceding aspect, optionally wherein the lambda light chains provide a repertoire of human lambda variable regions derived from human V λ gene segments V λ 3-1 and optionally one or more of V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8 and V λ 4-3 that have been provided in the genome by targeted insertion into said light chain locus.
- 35 This is useful because V λ 3-1 is a highly-used lambda gene segment in humans (Fig 59;

Ignatovich *et al* 1997) and thus it is desirable that cells and vertebrates of the invention provide for the inclusion of lambda variable regions based on this gene segment for selection against antigen, particularly for the development of antibody therapeutics for human use.

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15. The vertebrate or cell of any preceding aspect, optionally wherein the lambda light chains provide a repertoire of human lambda variable regions derived from human V λ gene segments V λ 2-14 and one or more of V λ 2-18, V λ 3-16, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8, V λ 4-3 and V λ 3-1 that have been provided in the genome by targeted
10 insertion into said light chain locus.

This is useful because V λ 2-14 is a highly-used lambda gene segment in humans and thus it is desirable that cells and vertebrates of the invention provide for the inclusion of lambda variable regions based on this gene segment for selection against antigen,
15 particularly for the development of antibody therapeutics for human use.

The vertebrate or cell of any preceding aspect, optionally wherein the lambda light chains provide a repertoire of human lambda variable regions derived from human V λ gene segments V λ 2-8 and one or more of V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 3-
20 10, V λ 3-9, V λ 2-8, V λ 4-3 and V λ 3-1 that have been provided in the genome by targeted insertion into said light chain locus.

This is useful because V λ 2-8 is a highly-used lambda gene segment in humans and thus it is desirable that cells and vertebrates of the invention provide for the inclusion of
25 lambda variable regions based on this gene segment for selection against antigen, particularly for the development of antibody therapeutics for human use.

The vertebrate or cell of any preceding aspect, optionally wherein the lambda light chains provide a repertoire of human lambda variable regions derived from human V λ gene segments V λ 3-10 and one or more of V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 2-14, V λ 3-9, V λ 2-8, V λ 4-3 and V λ 3-1 that have been provided in the genome by
30 targeted insertion into said light chain locus.

This is useful because V λ 3-10 is a highly-used lambda gene segment in humans and thus it is desirable that cells and vertebrates of the invention provide for the inclusion of
35 lambda variable regions based on this gene segment for selection against antigen,

particular for the development of antibody therapeutics for human use.

16. The vertebrate or cell of any preceding aspect, optionally wherein the human $V\lambda$ gene segments comprise the functional $V\lambda$ comprised by a human lambda chain Ig locus from $V\lambda 2-18$ to $V\lambda 3-1$.

For example, the human $V\lambda$ gene segments comprise at least human V gene segment $V\lambda 3-1$ or at least segments $V\lambda 2-18$, $V\lambda 3-16$, $V\lambda 2-14$, $V\lambda 3-12$, $V\lambda 2-11$, $V\lambda 3-10$, $V\lambda 3-9$, $V\lambda 2-8$, $V\lambda 4-3$ and $V\lambda 3-1$.

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17. The vertebrate of any preceding aspect, optionally wherein the vertebrate expresses more lambda chains than kappa chains. Lambda chains comprise variable regions derived from recombination of $V\lambda$ and $J\lambda$ gene segments – for example, expressed with a lambda constant region. Kappa chains comprise variable regions derived from recombination of $V\kappa$ and $J\kappa$ gene segments – for example, expressed with a kappa constant region.

18. The vertebrate of any preceding aspect, optionally wherein the vertebrate expresses no endogenous kappa chains. For example, endogenous kappa chain expression can be inactivated by any of the means described herein, such as by inversion of all or part of the endogenous kappa VJ region or by insertion of a marker (eg, neo) or other interfering sequence in an endogenous kappa locus (a locus not comprising human lambda gene segments according to the invention).

19. The vertebrate of any preceding aspect, optionally wherein kappa chain expression is substantially or completely inactive in said vertebrate. In one example, less than 10, 5, 4, 3, 2, 1 or 0.5% of light chains are provided by kappa chains.

20. The vertebrate or cell of any preceding aspect, optionally wherein a human $E\lambda$ enhancer is inserted in said endogenous non-human vertebrate locus. For example, there is inserted a human 5' MAR and human $E\lambda$ (and optionally the human 3' MAR) in germline configuration. For example, there is inserted a sequence corresponding to the human lambda intronic region immediately 3' of human $J\lambda 7-C\lambda 7$ to, and including, at least the human $E\lambda$ (and optionally also the human 3' MAR) – optionally including at least 30kb of

intronic region 3' of the human E λ .

21. The vertebrate or cell of any preceding aspect, wherein optionally at least human JC gene segments J λ 1-C λ 1, J λ 2-C λ 2, J λ 3-C λ 3, J λ 6-C λ 6 and J λ 7-C λ 7 are inserted in addition to the other human gene segments.
22. The vertebrate or cell of any preceding aspect, wherein optionally the inserted human gene segments are in germline configuration; optionally with the human inter-gene segment sequences or the corresponding endogenous non-human vertebrate inter-gene segment sequences.
23. The vertebrate or cell of any preceding aspect, wherein optionally an endogenous non-human vertebrate light chain enhancer is maintained in the endogenous locus; optionally in germline configuration. For example, when the endogenous locus is a kappa locus, an endogenous kappa enhancer is maintained. This can be the iE κ and/or the 3'E κ , optionally in germline configuration with respect to an endogenous light chain constant region. This may be useful to help control of light chain expression in the non-human vertebrate or cell.
2024. The vertebrate or cell of any preceding aspect, optionally wherein the genome is heterozygous for the human lambda insertion at the endogenous locus. For example, heterozygous for the human VJ or VJC insertion at an endogenous kappa (eg, mouse or rat kappa) locus. This aids and simplifies breeding of the vertebrates since the other endogenous locus (eg, the other kappa locus) can be used to provide a different transgenic Ig locus, such as a transgenic kappa locus comprising human kappa V and J gene segments either upstream of the endogenous mouse kappa constant region or upstream of a human kappa constant region. In this case, the kappa enhancers (iE κ and/or the 3'E κ) can be maintained in that kappa locus to aid expression in the vertebrate by using endogenous control mechanisms.
- In another embodiment, there is provided a non-human vertebrate or cell according to any preceding aspect, wherein
- (a) the endogenous locus is an endogenous lambda locus (eg, in a mouse), the genome being heterozygous for the insertion at the lambda locus, thus one allele of the

lambda locus comprising the human V λ and J λ gene segment insertion (optionally with the human C λ gene segment insertion; optionally with the human E λ insertion) as described above;

- (b) the other endogenous lambda allele comprises a plurality of human V κ gene segments and one or more human J κ gene segments upstream of a constant region (eg, a kappa constant region of said non-human vertebrate species; a human kappa constant region; the endogenous lambda constant region; or a human lambda constant region); optionally with one or more kappa enhancers (eg, iE κ and/or the 3'E κ , eg, of said non-human vertebrate species); and
- (c) endogenous lambda and kappa chain expression has been inactivated.

Thus, there is no expression of light chains comprising variable regions derived from recombination of endogenous V and J regions, but there is expression of human lambda and human kappa light chains from the alleles at the endogenous lambda locus. This is beneficial, since the design greatly aids construction and breeding of vertebrates by avoiding need to provide transgenic loci at both the endogenous lambda and kappa loci. The endogenous kappa locus (and thus endogenous kappa chain expression) can be inactivated by inversion, deletion of kappa gene segments (eg, endogenous V and/or J and/or C kappa) and/or by insertion of an interrupting sequence such as a marker (eg, neo) into the endogenous kappa locus.

The human kappa segment insertion into the endogenous lambda can be carried out, for example, by inserting a sequence corresponding to a portion of a human kappa locus comprising in germline configuration all functional human V κ and J κ (ie, optionally excluding pseudogenes and ORFs; see the IMGT database); and optionally also a human iE κ .

25. The vertebrate or cell of aspect 24, optionally wherein the genome comprises said human lambda gene segment insertion at one endogenous non-human vertebrate kappa locus allele, and wherein the other endogenous kappa locus allele comprises an insertion of human kappa immunoglobulin V and J genes upstream of an endogenous non-human vertebrate kappa constant region; optionally wherein an endogenous kappa light chain enhancer is maintained in one or both kappa locus; optionally in germline configuration.

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The vertebrate or cell of aspect 24, optionally wherein the genome comprises said

- human lambda gene segment insertion at one endogenous non-human vertebrate lambda locus allele, and wherein the other endogenous lambda locus allele comprises an insertion of human kappa immunoglobulin V and J genes upstream of an endogenous non-human vertebrate kappa constant region; optionally wherein an
- 5 endogenous lambda light chain enhancer is maintained in one or both lambda locus; optionally in germline configuration.
26. The vertebrate or cell of claim 24, optionally wherein the genome comprises said human lambda gene segment insertion at one endogenous non-human vertebrate lambda locus
- 10 allele, and wherein the other endogenous lambda locus allele comprises an insertion of human kappa immunoglobulin V and J genes upstream of an endogenous non-human vertebrate kappa constant region; optionally wherein an endogenous lambda light chain enhancer is maintained in one or both kappa locus; optionally in germline configuration.
1527. The vertebrate or cell of any one of aspects 1 to 23, optionally wherein the genome is homozygous for the human lambda insertion at the endogenous non-human vertebrate locus.
28. The vertebrate or cell of any one of aspects 1 to 23, optionally wherein the genome is
- 20 homozygous for a human lambda gene segment insertion at the endogenous non-human vertebrate kappa and lambda loci.
29. The vertebrate or cell of any one of aspects 1 to 23 and 28, optionally wherein the genome is homozygous for a human lambda gene segment insertion at the endogenous
- 25 non-human vertebrate lambda loci, one endogenous kappa locus allele comprising a human lambda gene segment insertion and the other endogenous kappa locus allele comprising an insertion of a plurality of human Vk and Jk gene segments upstream of a Ck region for the expression of kappa light chains comprising human kappa variable regions. Human kappa variable regions are those derived from the recombination of
- 30 human Vk and Jk.
30. The vertebrate or cell of aspect 27 or 28, optionally wherein the human lambda gene segment insertions at the kappa and lambda loci are insertions of the same repertoire of

human lambda gene segments.

31. The vertebrate or cell of aspect 27 or 28, optionally wherein the human lambda gene segment insertions at the kappa loci are different from the human lambda gene segment insertions at the lambda loci. This is useful for expanding the potential repertoire of variable regions for subsequent selection against antigen.
32. A non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising the following light chain loci arrangement
- (a) L at one endogenous kappa chain allele and K at the other endogenous kappa chain allele; or
 - (b) L at one endogenous lambda chain allele and K at the other endogenous lambda chain allele; or
 - (c) L at both endogenous kappa chain alleles;
 - (d) L at both endogenous lambda chain alleles;
 - (e) L at one endogenous kappa chain allele and the other endogenous kappa chain allele has been inactivated; or
 - (f) L at one endogenous lambda chain allele and the other endogenous lambda chain allele has been inactivated;

Wherein

L represents a human lambda gene segment insertion of at least the functional human V λ and J λ (optionally also C λ gene segments) comprised by a human lambda chain Ig locus from V λ 3-1 to C λ 7 (eg, comprised by a human lambda chain Ig locus from 2-18 to C λ 7); and

K represents a human V κ and J κ insertion;

Wherein in the genome the human gene segments are inserted upstream of a constant region for expression of light chains comprising variable regions derived from the recombination of human V and J gene segments.

33. The vertebrate or cell according to aspect 32, optionally wherein the genome comprises arrangement

(a) and L at one or both endogenous lambda chain alleles; or

5 (a) and K at one or both endogenous lambda chain alleles; or

(a) and L at one endogenous lambda chain allele and K at the other endogenous lambda chain allele; or

(b) and L at one or both endogenous kappa chain alleles; or

10 (b) and K at one or both endogenous kappa chain alleles; or

(b) and L at one endogenous kappa chain allele and K at the other endogenous kappa chain allele; or

(c) and K at one or both endogenous lambda chain alleles; or

15 (c) and L at one or both endogenous lambda chain alleles; or

(c) and L at one endogenous lambda chain allele and K at the other endogenous lambda chain allele; or

(c) and both endogenous lambda chain alleles have been inactivated; or

20 (d) and L at one or both endogenous kappa chain alleles; or

(d) and K at one or both endogenous kappa chain alleles; or

(d) and L at one endogenous kappa chain allele and K at the other endogenous kappa chain allele; or

(d) and both endogenous kappa chain alleles have been inactivated.

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34. The vertebrate or cell of aspect 32 or 33, optionally wherein endogenous kappa chain expression is substantially or completely inactivated. Endogenous kappa chains are kappa light chains comprising variable regions derived from the recombination of endogenous (non-human vertebrate) Vk and Jk gene segments.

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35. The vertebrate or cell of aspect 32, 33 or 34, optionally wherein endogenous lambda chain expression is substantially or completely inactive. Endogenous lambda chains are lambda light chains comprising variable regions derived from the recombination of endogenous (non-human vertebrate) Vλ and Jλ gene segments.

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36. The vertebrate or cell of any one of aspects 32 to 35, optionally wherein each L insertion is upstream of an endogenous lambda or kappa constant region.

37. The vertebrate or cell of any one of aspects 32 to 36, optionally wherein each L insertion
5 into a lambda locus is upstream of an endogenous lambda constant region.

38. The vertebrate or cell of any one of aspects 32 to 36, optionally wherein each L insertion into a kappa locus is upstream of an endogenous kappa constant region.

1039. The vertebrate or cell of any one of aspects 32 to 35, optionally wherein each L insertion into a lambda locus is upstream of a human lambda constant region.

40. The vertebrate or cell of any one of aspects 32 to 35, optionally wherein each L insertion into a kappa locus is upstream of a human kappa constant region.
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41. The vertebrate or cell of any one of aspects 32 to 40, optionally wherein each K insertion is upstream of an endogenous lambda or kappa constant region.

42. The vertebrate or cell of any one of aspects 32 to 41, optionally wherein each K insertion
20 into a lambda locus is upstream of an endogenous lambda constant region.

43. The vertebrate or cell of any one of aspects 32 to 42, optionally wherein each K insertion into a kappa locus is upstream of an endogenous kappa constant region.

2544. The vertebrate or cell of any one of aspects 32 to 40, optionally wherein each K insertion into a lambda locus is upstream of a human lambda constant region.

45. The vertebrate or cell of any one of aspects 32 to 40 and 44, optionally wherein each K
insertion into a kappa locus is upstream of a human kappa constant region.
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46. The vertebrate or cell of any one of aspects 32 to 45, optionally wherein the insertions are according to any one of aspects 1 to 9, 11 to 16 and 20 to 31.
47. The vertebrate or cell of any one of aspects 32 to 46, optionally wherein each human
5 lambda insertion is according to any one of aspects 1 to 9, 11 to 16 and 20 to 31.
48. The vertebrate or cell of any one of aspects 32 to 47, optionally wherein each human kappa insertion is according to any one of aspects 1 to 9, 11 to 16 and 20 to 31.
1049. The vertebrate or cell of any one of aspects 32 to 48, optionally wherein each human lambda insertion comprises the repertoire of human V λ and J λ (and optionally C λ) gene segments.
50. The vertebrate or cell of any one of aspects 32 to 48, optionally wherein first and second
15 (and optionally third) human lambda insertions are made and the insertions comprise different repertoires of human V λ and J λ (and optionally C λ) gene segments.
51. The vertebrate or cell of any one of aspects 32 to 50, optionally wherein each human kappa insertion comprises the repertoire of human V κ and J κ (and optionally C κ) gene
20 segments.
52. The vertebrate or cell of any one of aspects 32 to 50, optionally wherein first and second (and optionally third) human kappa insertions are made and the insertions comprise different repertoires of human V κ and J κ (and optionally C κ) gene segments.
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53. The vertebrate or cell of any preceding aspect, optionally wherein the genome comprises an immunoglobulin heavy chain locus comprising human V H gene segments, eg, a heavy chain locus as herein described which comprises human V, D and J gene segments..
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54. A method for producing an antibody or light chain comprising a lambda variable region specific to a desired antigen, the method comprising immunizing a vertebrate according

to any preceding aspect with the desired antigen and recovering the antibody or light chain or recovering a cell producing the antibody or light chain.

55. A method for producing a fully humanised antibody or antibody light chain comprising
5 carrying out the method of aspect 54 to obtain an antibody or light chain comprising a lambda chain non-human vertebrate constant region, and replacing the non-human vertebrate constant region with a human constant region, optionally by engineering of the nucleic acid encoding the antibody or light chain.
1056. A humanised antibody or antibody light chain produced according to aspect 54 or a derivative thereof; optionally for use in medicine.
57. Use of a humanised antibody or chain produced according to aspect 54 or a derivative thereof in medicine.
- 15
58. A method of inactivating endogenous Ig-VJ regions in the genome of a non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell), wherein the method comprises inserting human immunoglobulin gene segments (eg, V and J gene segments) in the genome between the endogenous Ig-VJ and an
20 endogenous enhancer or endogenous constant region to move the endogenous Ig-VJ away from the enhancer or constant region, thereby inactivating endogenous Ig-VJ regions.
- In one embodiment, the endogenous Ig-VJ are heavy chain gene segments, the
25 enhancer is an endogenous heavy chain enhancer, the constant region is an endogenous heavy chain constant region and the human Ig gene segments comprise human VH, DH and JH gene segments.
- In one embodiment, the endogenous Ig-VJ are lambda light chain gene segments, the
30 enhancer is an endogenous lambda chain enhancer, the constant region is an endogenous lambda chain constant region and the human Ig gene segments comprise human V λ and J λ gene segments.
- In one embodiment, the endogenous Ig-VJ are kappa light chain gene segments, the

enhancer is an endogenous kappa chain enhancer, the constant region is an endogenous kappa chain constant region and the human Ig gene segments comprise human Vk and Jk gene segments.

- 5 A method of inactivating endogenous IgK-VJ regions in the genome of a non-human vertebrate or a non-human vertebrate cell (eg, a mouse, rat, mouse cell or a rat cell), wherein the method comprises inserting human immunoglobulin gene segments in the genome between the endogenous IgK-VJ and Ek enhancer to move the IgK-VJ away from the Ek enhancer, thereby inactivating endogenous IgK-VJ regions.

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59. The method of aspect 58, wherein optionally the human gene segments comprise human VL and JL gene segments; optionally wherein the insertion is an insertion as recited in any one of aspects 1 to 9, 11 to 16 and 20 to 31 or an insertion of human Vk and Jk gene segments.

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60. A method of expressing immunoglobulin light chains in a non-human vertebrate (eg, a mouse or rat), the light chains comprising lambda variable regions (lambda light chains), wherein at least 70 or 80% (for example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99%) of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human Vλ and Jλ gene segments, the method comprising providing in the genome of the vertebrate an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human Vλ and Jλ gene segments upstream of a constant region, wherein the method comprises inserting at least the functional human Vλ and Jλ (optionally also human Cλ) gene segments (and optionally inter-gene segment sequences) comprised by a human lambda chain Ig locus from Vλ2-18 to Cλ7 into an endogenous light chain locus of the vertebrate, wherein at least 70 or 80% (for example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99%) of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human Vλ and Jλ gene segments; the method comprising expressing said light chains in the vertebrate and optionally isolating one or more of said light chains (eg, as part of a 4-chain antibody).

- In one embodiment, the method further comprises isolating from the vertebrate a lambda light chain comprising a variable region derived from recombination of human Vλ and Jλ gene segments. In an example, the method comprises immunising the mouse with an

antigen (eg, a human antigen) prior to isolating the lambda light chain. In an example, the light chain is part of an antibody, eg, an antibody that specifically binds the antigen.

In one embodiment, the use further comprises isolating splenic tissue (eg, the spleen) from the mouse; optionally followed by isolating at least one antigen-specific B-cell from the tissue, wherein the B-cell(s) expresses said lambda light chain. For example, said lambda light chain is provided by an antibody that specifically binds a predetermined antigen (eg, a human antigen). In one example, the use comprises immunising the mouse with the antigen (eg, a human antigen) prior to isolating the splenic tissue or lambda light chain. In an example, the use comprises isolating the lambda light chain produced by the B-cell (or by a hybridoma produced by fusion of the B-cell with a myeloma cell). In an example, the use comprises making a hybridoma from a B-cell isolated from the splenic tissue, wherein the hybridoma expresses said lambda light chain or a derivative thereof. Optionally, the use comprises making a derivative of the isolated antibody or lambda light chain. Examples of derivative antibodies (according to any aspect herein) are antibodies that have one or more mutations compared to the isolated antibody (eg, to improve antigen-binding affinity and/or to enhance or inactivate Fc function). Such mutants specifically bind the antigen. Mutation or adaptation to produce a derivative includes, eg, mutation to produce Fc enhancement or inactivation. A derivative can be an antibody following conjugation to a toxic payload or reporter or label or other active moiety. In another example, a chimaeric antibody chain or antibody isolated from a cell of vertebrate of the invention is modified by replacing one or all human constant regions thereof by a corresponding human constant region. For example, all constant regions of an antibody isolated from such a cell or vertebrate are replaced with human constant regions to produce a fully human antibody (ie, comprising human variable and constant regions). Such an antibody is useful for administration to human patients to reduce anti-antibody reaction by the patient.

61. A method of expressing immunoglobulin light chains in a non-human vertebrate (eg, a mouse or rat), wherein at least 60% (for example, at least 65, 70, 80, 84, 85, 90, 95, 96, 97, 98 or 99%) of the light chains expressed by the vertebrate are provided by human lambda light chains, the method comprising providing in the genome of the vertebrate an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising (i) human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments are provided by inserting at least the functional human V λ and J λ (optionally also human

Cλ) gene segments (and optionally inter-gene segment sequences) comprised by a human lambda chain Ig locus from Vλ2-18 to Cλ7 into an endogenous light chain locus of the vertebrate and (ii) kappa V gene segments upstream of a constant region, wherein the vertebrate expresses immunoglobulin light chains comprising human lambda
5 variable regions (human lambda light chains) and at least 60% (for example, greater than 65, 70, 80, 84, 85, 90, 95, 96, 97, 98 or 99%) of the light chains expressed by the vertebrate are provided by said human lambda light chains; the method comprising expressing said light chains in the vertebrate and optionally isolating one or more of said light chains (eg, as part of a 4-chain antibody).

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In one embodiment, the method further comprises isolating from the vertebrate a lambda light chain comprising a variable region derived from recombination of human Vλ and Jλ gene segments. In an example, the method comprises immunising the mouse with an antigen (eg, a human antigen) prior to isolating the lambda light chain. In an example,
15 the light chain is part of an antibody, eg, an antibody that specifically binds the antigen.

In one embodiment, the use further comprises isolating splenic tissue (eg, the spleen) from the mouse; optionally followed by isolating at least one antigen-specific B-cell from the tissue, wherein the B-cell(s) expresses said lambda light chain. For example, said
20 lambda light chain is provided by an antibody that specifically binds a predetermined antigen (eg, a human antigen). In one example, the use comprises immunising the mouse with the antigen (eg, a human antigen) prior to isolating the splenic tissue or lambda light chain. In an example, the use comprises isolating the lambda light chain produced by the B-cell (or by a hybridoma produced by fusion of the B-cell with a
25 myeloma cell). In an example, the use comprises making a hybridoma from a B-cell isolated from the splenic tissue, wherein the hybridoma expresses said lambda light chain or a derivative thereof. Optionally, the use comprises making a derivative of the isolated antibody or lambda light chain. Examples of derivative antibodies (according to any aspect herein) are antibodies that have one or more mutations compared to the
30 isolated antibody (eg, to improve antigen-binding affinity and/or to enhance or inactivate Fc function) Such mutants specifically bind the antigen.

62. A method of expressing human immunoglobulin VJC light chains in a non-human vertebrate (eg, a mouse or rat), the method comprising providing in the genome of the
35 vertebrate an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, wherein the method comprises

inserting at least the functional human V λ , J λ and C λ gene segments (and optionally inter-gene segment sequences) comprised by a human lambda chain Ig locus from V λ 3-1 to C λ 7 (eg, comprised by a human lambda chain Ig locus from 2-18 to C λ 7) into an endogenous non-human vertebrate kappa light chain locus upstream of an endogenous non-human vertebrate kappa constant region for expression of a human VJC light chain; the method comprising expressing said light chains in the vertebrate and optionally isolating one or more of said light chains (eg, as part of a 4-chain antibody).

In one embodiment, the method further comprises isolating from the vertebrate a lambda light chain comprising a variable region derived from recombination of human V λ and J λ gene segments. In an example, the method comprises immunising the mouse with an antigen (eg, a human antigen) prior to isolating the lambda light chain. In an example, the light chain is part of an antibody, eg, an antibody that specifically binds the antigen.

In one embodiment, the use further comprises isolating splenic tissue (eg, the spleen) from the mouse; optionally followed by isolating at least one antigen-specific B-cell from the tissue, wherein the B-cell(s) expresses said lambda light chain. For example, said lambda light chain is provided by an antibody that specifically binds a predetermined antigen (eg, a human antigen). In one example, the use comprises immunising the mouse with the antigen (eg, a human antigen) prior to isolating the splenic tissue or lambda light chain. In an example, the use comprises isolating the lambda light chain produced by the B-cell (or by a hybridoma produced by fusion of the B-cell with a myeloma cell). In an example, the use comprises making a hybridoma from a B-cell isolated from the splenic tissue, wherein the hybridoma expresses said lambda light chain or a derivative thereof. Optionally, the use comprises making a derivative of the isolated antibody or lambda light chain. Examples of derivative antibodies (according to any aspect herein) are antibodies that have one or more mutations compared to the isolated antibody (eg, to improve antigen-binding affinity and/or to enhance or inactivate Fc function). Such mutants specifically bind the antigen.

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63. The method of any one of aspects 38 to 40, optionally wherein the vertebrate is according to any one of the other aspects.

64. An antibody light chain isolated according to the method of any one of aspects 58 to 63 or a derivative thereof, or an antibody comprising such a light chain or derivative;

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optionally for use in medicine.

65. Use of an antibody light chain isolated according to the method of any one of aspects 58 to 63 or a derivative thereof (or an antibody comprising such a light chain or derivative) in medicine.

66. A non-human vertebrate (eg, a mouse or rat) according to any one of aspects 1 to 53 for expressing light chains comprising lambda variable regions (lambda light chains), wherein at least 70 or 80% (for example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99% or 100%) of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human V λ and J λ gene segments.

A non-human vertebrate (eg, a mouse or rat) according to any one of aspects 1 to 53 expressing light chains comprising lambda variable regions (lambda light chains), wherein at least 70 or 80% (for example, at least 70, 75, 80, 84, 85, 90, 95, 96, 97, 98 or 99% or 100%) of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human V λ and J λ gene segments.

67. A non-human vertebrate (eg, a mouse or rat) according to any one of aspects 1 to 53 for expressing light chains, wherein at least 60% (for example, greater than 65, 70, 80, 84, 85, 90, 95, 96, 97, 98 or 99% or 100%) of the light chains expressed by the vertebrate are provided by human lambda light chains.

A non-human vertebrate (eg, a mouse or rat) according to any one of aspects 1 to 53 expressing light chains, wherein at least 60% (for example, greater than 65, 70, 80, 84, 85, 90, 95, 96, 97, 98 or 99% or 100%) of the light chains expressed by the vertebrate are provided by human lambda light chains.

68. A non-human vertebrate (eg, a mouse or rat) according to aspect 7 for expressing light chains comprising lambda variable regions (lambda light chains), wherein expression of lambda light chains comprising human lambda variable regions dominates over expression of lambda light chains comprising endogenous non-human vertebrate lambda variable regions: and optionally for inactivating expression of endogenous non-human vertebrate lambda variable regions from the endogenous light chain locus.

A non-human vertebrate (eg, a mouse or rat) according to aspect 7 expressing light

chains comprising lambda variable regions (lambda light chains), wherein expression of lambda light chains comprising human lambda variable regions dominates over expression of lambda light chains comprising endogenous non-human vertebrate lambda variable regions: and optionally for inactivating expression of endogenous non-human vertebrate lambda variable regions from the endogenous light chain locus.

69. A non-human vertebrate (eg, a mouse or rat) according to aspect 7, 8, 9 or 10 for inactivating expression of endogenous non-human vertebrate lambda variable regions from the endogenous light chain locus.

10 The percentage expression or level of expression of antibody chains can be determined at the level of light chain mRNA transcripts in B-cells (eg, peripheral blood lymphocytes). Alternatively or additionally, the percentage expression is determined at the level of antibody light chains in serum or blood of the vertebrates. Additionally or alternatively, the expression can be determined by FACS (fluorescence activated cell sorting) analysis of B cells. For example, by assessing mouse C kappa or human C lambda expression on cell surface when the human lambda variable regions are expressed with mouse C kappa or human C lambda regions respectively.

The term a "lambda light chain" in these aspects refers to a light chain comprising a variable region sequence (at RNA or amino acid level) derived from the recombination of V λ and J λ gene segments. Thus a "human lambda variable region", for example, is a variable region derived from the recombination of human V λ and J λ gene segments. The constant region can be a kappa or lambda constant region, eg, a human or mouse constant region.

The vertebrate in these aspects is, for example naïve (ie, not immunised with a predetermined antigen, as the term is understood in the art; for example, such a vertebrate that has been kept in a relatively sterile environment as provided by an animal house used for R&D). In another example, the vertebrate has been immunised with a predetermined antigen, eg, an antigen bearing a human epitope.

Reference to "functional" human gene segments acknowledges that in a human Ig lambda locus some V gene segments are non-functional pseudogenes (eg, V λ 3-17, V λ 3-15, V λ 3-13, V λ 3-7, V λ 3-6, V λ 2-5, V λ 3-4, V λ 3-2; see the IMGT database: at World Wide Web (www.imgt.org/IMGTrepertoire/index.php?section=LocusGenes&repertoire=locus&species=human&group=IGL). Also, J λ 4-C λ 4 and J λ 5-C λ 5 are not functional in humans. The term

“functional” when referring to gene segments excludes pseudogenes. An example of functional human V λ gene segments is the group V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8, V λ 4-3 and V λ 3-1. An example of functional human J λ gene segments is the group J λ 1, J λ 2 and J λ 3; or J λ 1, J λ 2 and J λ 7; or J λ 2, J λ 3 and J λ 7; or
5 J λ 1, J λ 2, J λ 3 and J λ 7. An example of functional human C λ gene segments is the group C λ 1, C λ 2 and C λ 3; or C λ 1, C λ 2 and C λ 7; or C λ 2, C λ 3 and C λ 7; or C λ 1, C λ 2, C λ 3 and C λ 7.

In one embodiment, the lambda light chains, together with heavy chains expressed in
10 the cells or vertebrates of the invention, form antibodies. The heavy chains can be expressed from a transgenic heavy chain locus as herein described. For example the genome of the cell or vertebrate comprises a heavy chain locus in which is a chimaeric immunoglobulin heavy chain locus comprising one or more human V gene segments, one or more human D gene segments and one or more human J gene segments
15 upstream of a mu constant region of said non-human species; endogenous heavy chain expression has been substantially inactivated; and the heavy chain locus comprises an E μ enhancer of said non-human vertebrate species.

In one embodiment of the vertebrate or cell, all endogenous enhancers are deleted from the endogenous locus in which the human gene segments are inserted. Thus, when a
20 human enhancer (eg, E λ) is inserted, this controls the transgenic locus in the absence of the effect of other, endogenous, enhancers (for example, kappa enhancers if the locus is an endogenous kappa enhancer). This may be useful to avoid non-human vertebrate-like kappa:lambda expression ratios (eg, to steer expression to a higher ratio of lambda: kappa in mice).

25 When endogenous light chain (eg, kappa or lambda) expression is substantially inactive or inactivated as described herein, less than 10, 5, 4, 3, 2, 1 or 0.5% of such endogenous light chains are expressed or expressible. In one example, there is complete inactivation so no such light chains are expressed or expressible.

30 Optionally the vertebrate of the invention is naïve. Thus, the vertebrate has not been immunised with a predetermined antigen.

Where, for example, a cell of the invention is an ES cell or other IPS stem cell or other pluripotent stem cell, the cell can develop into a vertebrate of the invention. For
35 example, the cell can be implanted into a blastocyst from a foster mother and developed into an embryo and animal according to standard techniques.

In one embodiment, where human kappa gene segments are inserted, each insertion comprises human kappa gene segments

- (i) V κ 1-5, V κ 1-6, V κ 1-8 and V κ 1-9 (and optionally V κ 5-2 and V κ 4-1); or
- 5 (ii) V κ 1-5, V κ 1-6, V κ 1-8, V κ 1-9, V κ 3-11, V κ 1-12, V κ 3-15, V κ 1-16, V κ 1-17, V κ 3-20 (and optionally V κ 2-24 and/or V κ 1-13); or
- (iii) V κ 1-5, V κ 1-6, V κ 1-8, V κ 1-9, V κ 3-11, V κ 1-12, V κ 3-15, V κ 1-16, V κ 1-17, V κ 3-20, V κ 2-24, , V κ 1-27, V κ 2-28, V κ 2-30 and V κ 1-33 (and optionally V κ 2-29 and/or V κ 2-40 and/or V κ 1-39);

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and optionally

- (iv) J κ 1, J κ 2, J κ 3, J κ 4 and J κ 5.

- 15 In one embodiment, the human kappa insertion also comprises a human iE κ and/or human 3'E κ downstream of the human J gene segments in the locus.

Transgenic Mice of the Invention Expressing Essentially Exclusively Human Heavy Chain Variable Regions Develop Normal Splenic and BM Compartments & Normal Ig Expression In Which the Ig Comprise Human Heavy Chain Variable Regions

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The present inventors surprisingly observed normal Ig subtype expression & B-cell development in transgenic mice of the invention expressing antibodies with human heavy chain variable regions substantially in the absence of endogenous heavy and kappa chain expression. See Example 16 below.

- 25 The inventors observed that surprisingly the inactivation of endogenous heavy chain variable region expression in the presence of human variable region expression does not change the ratio of B-cells in the splenic compartment (Fig. 66) or bone marrow B progenitor compartment (Fig. 67) and the immunoglobulin levels in serum are normal and the correct Ig subtypes are expressed (Fig. 68). These data demonstrate that
- 30 inserted human heavy chain gene segments according to the invention (eg, an insertion of at least human V_H gene segments V_H2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6, optionally the alleles of Table 7) are fully functional for VDJ gene segment

rearrangement from the transgenic heavy chain locus, B-cell receptor (BCR) signalling and proper B-cell maturation

The invention therefore provides the following aspects (numbering starting at aspect 70):-

570. A mouse that expresses or for expressing immunoglobulin heavy chains comprising human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies in the mouse;

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the mouse comprising an immunoglobulin heavy chain locus comprising human VH, DH and JH gene segments upstream of a mouse constant region (eg, C-mu and/or C-delta and/or C-gamma; such as (in a 5' to 3' orientation) mouse C-mu and mouse C-delta and mouse C-gamma), wherein

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(a) the mouse is capable of expressing immunoglobulin heavy chains comprising human variable regions and the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions; and

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(b) the mouse expresses serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies comprising said heavy chains.

Ig isotypes can be determined, for example, using isotype-matched tool antibodies as will be readily familiar to the skilled person (and as illustrated in Example 16).

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In an embodiment, the mouse is naïve.

71. The mouse of aspect 70 for expressing a normal relative proportion of serum IgG1, IgG2a, IgG2b and IgM antibodies.

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By "normal" is meant comparable to expression in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

72. The mouse of aspect 70 or 71, wherein the mouse expresses a normal relative proportion of serum IgG1, IgG2a, IgG2b and IgM antibodies.

By "normal" is meant comparable to expression in a mouse (eg, a naïve mouse)

5 expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

73. The mouse of any one of aspects 70 to 72, for expressing in the mouse

- (i) serum IgG1 at a concentration of about 25-350 µg/ml;
- 10 (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
- (iv) serum IgM at a concentration of about 50-300 µg/ml;

or

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- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

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as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

25

For example, the mouse of any one of aspects 70 to 72, for expressing in the mouse

- 30 (i) serum IgG1 at a concentration of about 25-150 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-300 µg/ml; and
- (iv) serum IgM at a concentration of about 50-200 µg/ml;

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or

- (i) serum IgG1 at a concentration of about 10-200 µg/ml;

- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-400 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

5 as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate
10 (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

The mouse of any one of aspects 70 to 72, for expressing in the mouse Ig in the relative proportions of

- 15 (i) serum IgG1 at a concentration of about 25-350 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
- (iv) serum IgM at a concentration of about 50-300 µg/ml;

20 or

- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

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as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with
30 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

For example, the mouse of any one of aspects 70 to 72, for expressing in the mouse Ig
35 in the relative proportions of

- (i) serum IgG1 at a concentration of about 25-150 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;

- (iii) serum IgG2b at a concentration of about 30-300 µg/ml; and
- (iv) serum IgM at a concentration of about 50-200 µg/ml;

or

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- (i) serum IgG1 at a concentration of about 10-200 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-400 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

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as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

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74. The mouse of any one of aspects 70 to 73, wherein the mouse expresses

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- (i) serum IgG1 at a concentration of about 25-350 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
- (iv) serum IgM at a concentration of about 50-300 µg/ml;

25

or

- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

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as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to

35

stop development of the label and reading of the label at 450 nm).

For example, the mouse of any one of aspects 70 to 72, the mouse expresses

- (i) serum IgG1 at a concentration of about 25-150 µg/ml;
- 5 (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-300 µg/ml; and
- (iv) serum IgM at a concentration of about 50-200 µg/ml;

or

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- (i) serum IgG1 at a concentration of about 10-200 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-400 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

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as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 20 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

The mouse of any one of aspects 70 to 73, wherein the mouse expresses Ig in the 25 relative proportions of

- (i) serum IgG1 at a concentration of about 25-350 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
- (iv) serum IgM at a concentration of about 50-300 µg/ml;

30

or

- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- 35 (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

For example, the mouse of any one of aspects 70 to 72, the mouse expresses Ig in the relative proportions of

- (i) serum IgG1 at a concentration of about 25-150 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
- (iii) serum IgG2b at a concentration of about 30-300 µg/ml; and
- (iv) serum IgM at a concentration of about 50-200 µg/ml;

or

- (i) serum IgG1 at a concentration of about 10-200 µg/ml;
- (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
- (iii) serum IgG2b at a concentration of about 20-400 µg/ml; and
- (iv) serum IgM at a concentration of about 50-700 µg/ml;

as determined by Ig capture on a plate followed by incubation (eg, for one hour at RT, eg, for one hour at 20°C) with anti-mouse isotype-specific labelled antibodies and quantification of Ig using the label (eg, using anti-mouse Ig isotype specific antibodies each conjugated to horseradish peroxidase conjugated at a ratio of 1/10000 in PBS with 0.1% TweenTM, followed by development of the label with tetramethylbenzidine substrate (TMB) for 4-5 minutes in the dark at room temperature (eg, 20°C), adding sulfuric acid to stop development of the label and reading of the label at 450 nm).

75. The mouse of any one of aspects 70 to 74 for expressing said heavy chains from splenic B-cells in a mouse that produces a normal proportion or percentage of mature splenic B-cells, eg as determined by FACS.

By “normal” is meant comparable to mature splenic B-cell production in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome

comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

For example, at least 40, 50, 60 or 70 % of total splenic B-cells produced by the mouse of the invention are mature B-cells. Splenic B-cells are B220⁺ and express B220 at relatively high levels as the skilled person will know. Mature splenic B-cells express B220 and IgD, both at relatively high levels as will be known by the skilled person. IgM expression is relatively low in mature splenic B-cells, again as is known in the art. For example, see J Exp Med. 1999 Jul 5;190(1):75-89; "B cell development in the spleen takes place in discrete steps and is determined by the quality of B cell receptor-derived signals"; Loder F *et al*.

Optionally the mouse produces a normal ratio of T1, T2 and mature splenic B-cells, eg, as determined by FACS. For example, the mouse of the invention produces about 40-70% mature splenic B-cells, 15-35% splenic T1 cells; and 5-10% splenic T2 cells (percentage with reference to the total splenic B220-positive (high) population). For example, about 40-60% mature splenic B-cells, 15-30% splenic T1 cells; and 5-10% splenic T2 cells. By "normal" is meant comparable to a T1/T2/mature splenic B-cell proportion in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

76. The mouse of any one of aspects 70 to 75, wherein the mouse produces a normal proportion or percentage of mature splenic B-cells, eg as determined by FACS.

2577. A mouse that expresses or for expressing immunoglobulin heavy chains comprising human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions and are expressed in a mouse that produces a normal proportion or percentage of mature splenic B-cells (eg, as determined by FACS); the mouse comprising an immunoglobulin heavy chain locus comprising human VH, DH and JH gene segments upstream of a mouse constant region (eg, C-mu and/or C-delta and/or C-gamma; such as (in a 5' to 3' orientation) and wherein the mouse produces a normal proportion or percentage of mature splenic B-cells.

By "normal" is meant comparable to mature splenic B-cell production in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

For example, at least 40, 50, 60 or 70 % of total splenic B-cells produced by the mouse of the invention are mature B-cells. Splenic B-cells are B220⁺ and express B220 at relatively high levels as the skilled person will know. Mature splenic B-cells express B220 and IgD, both at relatively high levels as will be known by the skilled person. IgM expression is relatively low in mature splenic B-cells, again as is known in the art. For example, see J Exp Med. 1999 Jul 5;190(1):75-89; "B cell development in the spleen takes place in discrete steps and is determined by the quality of B cell receptor-derived signals"; Loder F *et al*.

Optionally the mouse produces a normal ratio of T1, T2 and mature splenic B-cells, eg, as determined by FACS. For example, the mouse of the invention produces about 40-70% mature splenic B-cells, 15-35% splenic T1 cells; and 5-10% splenic T2 cells (percentage with reference to the total splenic B220-positive (high) population). For example, about 40-60% mature splenic B-cells, 15-30% splenic T1 cells; and 5-10% splenic T2 cells. By "normal" is meant comparable to a T1/T2/mature splenic B-cell proportion in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

78. The mouse of any one of aspects 70 to 77 for expressing said heavy chains in a mouse that produces a normal proportion or percentage of bone marrow B-cell progenitor cells (eg as determined by FACS).

In one embodiment, the mouse is for expressing said heavy chains in a mouse that produces a normal proportion or percentage of bone marrow pre-, pro and prepro- B-cells (eg as determined by FACS). See J Exp Med. 1991 May 1;173(5):1213-25; "Resolution and characterization of pro-B and pre-pro-B cell stages in normal mouse bone marrow"; Hardy RR *et al* for more discussion on progenitor cells.

By "normal" is meant comparable to bone marrow B-cell production in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

3579. The mouse of any one of aspects 70 to 78, wherein the mouse produces a normal proportion or percentage of bone marrow B-cell progenitor cells (eg, as determined by FACS).

In one embodiment, the mouse produces a normal proportion or percentage of bone marrow pre-, pro and prepro- B-cells (eg as determined by FACS).

- 5 By “normal” is meant comparable to bone marrow B-cell production in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

80. A mouse that expresses or for expressing immunoglobulin heavy chains comprising
10 human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions and are expressed in a mouse that produces a normal proportion or percentage of bone marrow B-cell progenitor cells (eg, as determined by FACS), the mouse comprising an immunoglobulin heavy chain locus comprising human VH, DH and JH gene segments
15 upstream of a mouse constant region (eg, C-mu and/or C-delta and/or C-gamma; such as (in a 5' to 3' orientation) and wherein the mouse produces a normal proportion or percentage of bone marrow B-cell progenitor cells.

- In one embodiment, the mouse is for expressing said heavy chains in a mouse that
20 produces a normal proportion or percentage of bone marrow pre-, pro and prepro- B-cells (eg as determined by FACS).

- By “normal” is meant comparable to bone marrow B-cell production in a mouse (eg, a naïve mouse) expressing only mouse antibody chains, eg, a mouse whose genome
25 comprises only wild-type functional Ig heavy and light chain loci, eg, a wild-type mouse.

81. The mouse of any one of aspects 70 to 80, wherein at least 90% of the heavy chains are heavy chains comprising human variable regions.

- 30 For example, at least 90, 95, 96, 97, 98, 99 or 99.5% or 100% of the heavy chains comprise human variable regions, ie, variable regions derived from the recombination of human VH with human D and JH gene segments.

82. The mouse of any one of aspects 70 to 81, wherein the mouse constant region
35 comprises a mouse C-mu region, a C-delta region and a C-gamma region.

In one embodiment, each of the C regions is an endogenous, mouse C-region. In one embodiment at least the C-mu and the C-delta regions are mouse C regions. This is useful for harnessing the endogenous control mechanisms involved in the development of the various B-cell types and progenitors in the spleen and bone marrow.

5 In one embodiment, the C-gamma region is a human C-gamma region. This is beneficial for producing class-switched gamma-type heavy chains in the mouse in which essentially all of the expressed heavy chains have human variable regions and human constant regions.

83. The mouse of any one of aspects 70 to 82, wherein there is a mouse heavy chain
10 enhancer between the human gene segments and the mouse constant region. This is useful for harnessing the endogenous mouse antibody- and B-cell development control mechanisms.

84. The mouse of any one of aspects 70 to 83, wherein there is a mouse S-mu switch
15 between the human gene segments and the mouse constant region.

85. The mouse of any one of aspects 70 to 84, wherein the genome of the mouse comprises endogenous mouse heavy chain locus V, D and J gene segments upstream of the human gene segments.

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86. The mouse of aspect 85, wherein the mouse V, D and J gene segments are present together with the endogenous inter-gene segment sequences.

87. The mouse of aspect 85 or 86, wherein the mouse gene segments are in inverted
25 orientation. Thus, they are inverted with respect to the wild-type orientation in a mouse genome. They are thus inverted relative to the orientation of the mouse constant region.

88. The mouse of any one of aspects 70 to 87, wherein the mouse expresses light chains comprising human variable regions (eg, kappa light chains comprising human kappa
30 variable regions). Thus, the human variable regions are derived from the recombination of human VL and JL gene segments, eg, human Vk and human Jk.

89. The mouse of aspect 88, comprising human Vk and Jk gene segments upstream of a mouse CL (eg, endogenous Ck); optionally wherein the human Vk and Jk gene
35 segments comprise Vk2-24, Vk3-20, Vk1-17, Vk1-16, Vk3-15, Vk1-13, Vk1-12, Vk3-11, Vk1-9, Vk1-8, Vk1-6, Vk1-5, Vk5-2, Vk4-1, Jk1, Jk2, Jk3, Jk4 and Jk5. Optionally

wherein the gene segments are the alleles of Table 12.

90. The mouse of any one of aspects 70 to 89, wherein the human V_H, D_H and J_H gene segments comprise human V_H gene segments V_H2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6. For example, the human V_H, D_H and J_H gene segments comprise human V_H gene segments V_H2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 3-10, 4-11, 5-12, 6-13, 1-14, 2-15, 3-16, 4-17, 5-18, 6-19, 1-20, 2-21, 3-22, 4-23, 5-24, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6. Optionally wherein the gene segments are the alleles of Table 7.

91. Use of the mouse of any one of aspects 70 to 90 for expressing immunoglobulin heavy chains comprising human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies in the mouse. The use is non-therapeutic, non-diagnostic and non-surgical use.

In one embodiment, the use comprises immunising the mouse with an antigen (eg, a human antigen) and isolating an IgG1 antibody that specifically binds the antigen.

In one embodiment, the use comprises immunising the mouse with an antigen (eg, a human antigen) and isolating an IgG2a antibody that specifically binds the antigen.

In one embodiment, the use comprises immunising the mouse with an antigen (eg, a human antigen) and isolating an IgG2b antibody that specifically binds the antigen. Optionally, the use comprises making a derivative of the isolated antibody. Examples of derivative antibodies (according to any aspect herein) are antibodies that have one or more mutations compared to the isolated antibody (eg, to improve antigen-binding affinity and/or to enhance or inactivate Fc function) Such mutants specifically bind the antigen.

92. Use of the mouse of any one of aspects 70 to 90 for expressing immunoglobulin heavy chains comprising human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions and are expressed in a mouse that produces a normal proportion or percentage of

mature splenic B-cells. The use is non-therapeutic, non-diagnostic and non-surgical use.

5 In one embodiment, the use further comprises isolating splenic tissue (eg, the spleen) from the mouse; optionally followed by isolating at least one antigen-specific B-cell from the tissue, wherein the B-cell(s) expresses an antibody that specifically binds a predetermined antigen. In one example, the use comprises immunising the mouse with the antigen prior to isolating the splenic tissue. In an example, the use comprises isolating an antibody produced by the B-cell (or by a hybridoma produced by fusion of
10 the B-cell with a myeloma cell). Optionally, the use comprises making a derivative of the isolated antibody. Examples of derivative antibodies (according to any aspect herein) are antibodies that have one or more mutations compared to the isolated antibody (eg, to improve antigen-binding affinity and/or to enhance or inactivate Fc function) Such mutants specifically bind the antigen.

15

93. Use of the mouse of any one of aspects 70 to 90 for expressing immunoglobulin heavy chains comprising human variable regions, wherein the heavy chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions and are expressed in a mouse that produces a normal proportion or percentage of bone
20 marrow B-cell progenitor cells. The use is non-therapeutic, non-diagnostic and non-surgical use.

94. Use of the mouse of any one of aspects 70 to 90 for the purpose stated in one or more of aspects 70, 71, 73, 75 and 78.

25 The expression (eg, percentage expression or expression proportion or level) of Ig can be determined at the level of antibody chain mRNA transcripts in B-cells (eg, peripheral blood lymphocytes). Alternatively or additionally, the percentage expression is determined at the level of antibody in serum or blood of the vertebrates. Additionally or alternatively, the expression can be determined by FACS analysis of B cells.

30 In these aspects, "heavy chains comprising human variable regions" means variable regions derived from the recombination of human VH, D and JH gene segments.

"Essentially exclusively" the expressed heavy chains comprise human variable regions, ie, there is only a relatively very low or even no endogenous mouse heavy chain variable region expression. For example, at least 90, 95, 96, 97, 98, 99 or 99.5% or 100% of the
35 heavy chains are heavy chains comprising human variable regions. In one embodiment,

at least 90% of the heavy chains are heavy chains comprising human variable regions. The percentage expression can be determined at the level of heavy chain mRNA transcripts in B-cells (eg, peripheral blood lymphocytes). Alternatively or additionally, the percentage expression is determined at the level of heavy chains or antibodies in serum or blood of the mice. Additionally or alternatively, the expression can be determined by FACS analysis of B-cells.

The mouse can comprise any endogenous heavy chain locus in which human V, D and J gene segments are present, as described herein. In one example, the mouse genome comprises a mouse heavy chain locus in which at least human V_H gene segments V_H2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6 are upstream of the mouse constant region.

The vertebrate in these aspects is, for example naïve (ie, not immunised with a predetermined antigen, as the term is understood in the art; for example, such a vertebrate that has been kept in a relatively sterile environment as provided by an animal house used for R&D). In another example, the vertebrate has been immunised with a predetermined antigen, eg, an antigen bearing a human epitope.

In one embodiment, the heavy chains, together with light chains expressed in the mice of the invention, form antibodies (Ig). The light chains can be expressed from any transgenic light chain locus as herein described. For example the genome of the mouse comprises a heavy chain locus in which is a chimaeric immunoglobulin heavy chain locus comprising one or more human V gene segments, one or more human D gene segments and one or more human J gene segments upstream of a mu constant region of said non-human species; endogenous heavy chain expression has been substantially inactivated; and the heavy chain locus comprises an E_μ enhancer of said non-human vertebrate species.

In one embodiment of any aspect, endogenous light chain (eg, kappa and/or lambda) expression is substantially inactive or inactivated, for example using method as described herein. In this case, less than 10, 5, 4, 3, 2, 1 or 0.5% of such endogenous lambda light chains are expressed or expressible. Additionally or alternatively, less than 10, 5, 4, 3, 2, 1 or 0.5% of such endogenous kappa light chains are expressed or expressible. In one example, there is complete inactivation of endogenous kappa and/or lambda expression so no such light chains are expressed or expressible.

In one embodiment, the genome of the mouse comprises human kappa gene segments (optionally the alleles of Table 12)

- (i) Vk1-5, Vk1-6, Vk1-8 and Vk1-9 (and optionally Vk5-2 and Vk4-1); or
- (ii) Vk1-5, Vk1-6, Vk1-8, Vk1-9, Vk3-11, Vk1-12, Vk3-15, Vk1-16, Vk1-17, Vk3-20
5 (and optionally Vk 2-24 and/or Vk1-13); or
- (iii) Vk1-5, Vk1-6, Vk1-8, Vk1-9, Vk3-11, Vk1-12, Vk3-15, Vk1-16, Vk1-17, Vk3-20, Vk 2-24, , Vk1-27, Vk2-28, Vk2-30 and Vk1-33 (and optionally Vk 2-29 and/or Vk2-40 and/or Vk1-39);
- 10 and optionally
- (iv) Jk1, Jk2, Jk3, Jk4 and Jk5.

In one embodiment, the genome also comprises (i) at least human V_H gene segments
15 V_H2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6 (optionally the alleles of Table 7) and (ii) at least human gene segments Vk2-24, Vk3-20, Vk1-17, Vk1-16, Vk3-15, Vk1-13, Vk1-12, Vk3-11, Vk1-9, Vk1-8, Vk1-6, Vk1-5, Vk5-2, Vk4-1, Jk1, Jk2, Jk3, Jk4 and Jk5 (optionally
20 the alleles of Table 12). As demonstrated in Example 16, such mice are fully functional in the aspect of rearrangement, BCR signalling and B cell maturation. Greater than 90% of the antibodies expressed by the mice comprised human heavy chain variable regions and human kappa light chain variable regions. These mice are, therefore, very useful for the selection of antibodies having human variable regions that specifically bind human
25 antigen following immunisation of the mice with such antigen. Following isolation of such an antibody, the skilled person can replace the mouse constant regions with human constant regions using conventional techniques to arrive at totally human antibodies which are useful as drug candidates for administration to humans (optionally following mutation or adaptation to produce a further derivative, eg, with Fc enhancement or
30 inactivation or following conjugation to a toxic payload or reporter or label or other active moiety).

In one embodiment, the genome also comprises a human iE_k and/or human 3'E_k downstream of the human J gene segments in the locus.

The invention also includes the following clauses:

Clause 1. A mouse that expresses immunoglobulin heavy chains containing human variable regions,

wherein the mouse comprises a genome that includes an immunoglobulin heavy chain locus comprising human VH, DH, and JH gene segments positioned upstream to a mouse constant region;

wherein the mouse expresses immunoglobulin heavy chains, characterized in that at least 90% of the immunoglobulin heavy chains expressed by the mouse comprise a human variable region; and

wherein the mouse expresses serum IgG1, IgG2b, and IgM antibodies comprising said heavy chains containing a human variable region.

Clause 2. A mouse that expresses immunoglobulin heavy chains containing human variable regions,

wherein the mouse comprises a genome that includes an immunoglobulin heavy chain locus comprising human VH, DH, and JH gene segments which are positioned upstream to a mouse constant region;

wherein the mouse expresses immunoglobulin heavy chains, characterized in that at least 90% of the immunoglobulin heavy chains expressed by the mouse comprise a human variable region; and

wherein the mouse produces a normal proportion of mature splenic B-cells;

wherein said normal proportion is a proportion of mature splenic B-cells produced by a mouse that expresses immunoglobulin heavy chains containing mouse variable regions and does not express immunoglobulin heavy chains containing human variable regions.

Clause 3. A mouse that expresses immunoglobulin heavy chains containing human variable regions,

wherein the mouse comprises a genome that includes an immunoglobulin heavy chain locus comprising human VH, DH, and JH gene segments which are positioned upstream to a mouse constant region;

wherein the mouse expresses immunoglobulin heavy chains, characterized in that it at least 90% of the immunoglobulin heavy chains expressed by the mouse comprise a human variable region; and

5 wherein the mouse produces a normal proportion of bone marrow B-cell progenitor cells;

wherein the normal proportion is a proportion of bone marrow B-cell progenitor cells produced by a mouse that expresses immunoglobulin heavy chains containing mouse variable regions and does not expresses immunoglobulin heavy chains containing human variable regions.

10

Clause 4. The mouse of any of the preceding clauses, wherein the mouse expresses a normal proportion of IgG1, IgG2b, and IgM in a sample of serum obtained from the mouse;

15 wherein the normal proportion is as produced by a mouse that expresses immunoglobulin heavy chains containing mouse variable regions and does not expresses immunoglobulin heavy chains containing human variable regions.

Clause 5. The mouse of any of the preceding clauses, wherein the mouse constant region is C-mu , C-delta, and/or C-gamma.

20 Clause 6. The mouse of clause 5, wherein the mouse constant region is at least C-mu,C-delta and C-gamma.

Clause 7. The mouse of any of the preceding clauses, wherein the mouse constant region is an endogenous mouse C-region.

Clause 8. The mouse of any of the preceding clauses, wherein the mouse expresses a human C-gamma region.

25 Clause 9. The mouse of any of the preceding clauses, wherein the mouse is a naïve mouse.

Clause 10. The mouse of clause 1, wherein the mouse expresses serum IgG2a comprising said heavy chains containing a human variable region.

Clause 11. The mouse of any of the preceding clauses, wherein the mouse expresses Ig subtypes in a relative proportion of

- 5
- (i) serum IgG1 at a concentration of about 25-350 µg/ml;
 - (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
 - (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
 - (iv) serum IgM at a concentration of about 50-300 µg/ml;

Or

- 10
- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
 - (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
 - (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
 - (iv) serum IgM at a concentration of about 50-700 µg/ml;

as determined by immunoglobulin capture on a plate followed by incubation with an anti-mouse isotype-specific antibodies each comprising a label and quantification of each immunoglobulin based on the level of each label.

15 Clause 12. The mouse of any of the preceding clauses, wherein the mouse expresses Ig subtypes in a relative proportion of

- (i) total serum IgG and IgM at a concentration of about 200-2500 µg/ml; and
- (ii) serum IgM at a concentration of about 100-800 µg/ml;

20 as determined by immunoglobulin capture on a plate followed by incubation with an anti-mouse isotype-specific antibodies each comprising a label and quantification of each immunoglobulin based on the level of each label.

Clause 13. The mouse of any of the preceding clauses, wherein the mouse expresses said immunoglobulin heavy chains from splenic B-cells and wherein the mouse produces a normal proportion of mature splenic B-cells in total spleen cells comprising mature B-cells, and splenic T1 and T2 cells.

25

Clause 14. The mouse of any one of clauses 1-3, wherein, at least 95, 96, 97, 98, 99, or 99.5% of the immunoglobulin heavy chains expressed by the mouse are immunoglobulin heavy chains comprising human variable regions.

30

Clause 15. The mouse of any of the preceding clauses, wherein a mouse immunoglobulin heavy chain enhancer is positioned in said mouse heavy chain immunoglobulin locus between the human VH, DH, and JH gene segments and the mouse constant region.

- 5 Clause 16. The mouse of any of the preceding clauses, wherein a mouse S-mu switch is positioned in said mouse heavy chain immunoglobulin locus between the human VH, DH, and JH gene segments and the mouse constant region.

- Clause 17. The mouse of any of the preceding clauses, wherein endogenous mouse immunoglobulin heavy chain V, D and J gene segments are positioned in said mouse
10 heavy chain immunoglobulin locus upstream to the human VH, DH, and JH gene segments.

Clause 18. The mouse of clause 17, wherein the mouse immunoglobulin heavy chain V, D and J gene segments are present in said mouse heavy chain immunoglobulin locus with endogenous inter-gene segment sequences.

- 15 Clause 19. The mouse of clause 17 or 18, wherein the mouse immunoglobulin heavy chain V, D and J gene segments are positioned in said mouse heavy chain immunoglobulin locus in an orientation that is inverted relative to its natural endogenous orientation.

- Clause 20. The mouse of any of the preceding clauses, wherein the mouse
20 expresses light chains containing human kappa variable regions.

Clause 21. The mouse of clause 20, wherein the mouse expresses immunoglobulin light chains derived from recombination of Vk with human Jk.

- Clause 22. The mouse of any of the preceding clauses, wherein the mouse
25 expresses light chains containing human lambda variable regions.

Clause 23. The mouse of clause 22, wherein the mouse expresses immunoglobulin light chains derived from recombination of Vλ with human Jλ.

- Clause 24. The mouse of clause 21, comprising a genome that includes human Vk and Jk gene segments positioned in said mouse heavy chain immunoglobulin locus
30 upstream to a mouse CL.

Clause 25. The mouse of clause 24, wherein the mouse CL is an endogenous Cκ.

Clause 26. The mouse of clauses 24 or 25, wherein the human Vκ and Jκ gene segments comprise Vκ2-24, Vκ3-20, Vκ1-17, Vκ1-16, Vκ3-15, Vκ1-13, Vκ1-12, Vκ3-11, Vκ1-9, Vκ1-8, Vκ1-6, Vκ1-5, Vκ5-2, Vκ4-1, Jκ1, Jκ2, Jκ3, Jκ4 and Jκ5.

5 Clause 27. The mouse of any the preceding clauses, wherein the human VH, DH and JH gene segments contain

human VH gene segments: VH2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1;

human DH gene segments: D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and

10 human JH gene segments: J1, J2, J3, J4, J5 and J6.

Clause 28. A method for obtaining one or more immunoglobulin heavy chains containing human variable regions, comprising providing the mouse of any of the preceding clauses and

15 isolating one or more immunoglobulin heavy chains.

Clause 29. The method of clause 28, wherein each immunoglobulin heavy chain is included in an antibody.

20 Clause 30. The method of clause 29, wherein said heavy chain and/or said antibody containing said heavy chain is modified after said isolating.

Clause 31. The method of clause 28, wherein a step of immunizing the mouse with an antigen is performed before the step of isolating the immunoglobulin heavy chains.

25

Clause 31a. The method of clause 30, wherein the antigen is a human antigen.

Clause 32. The method of clause 30, 31, or 31a, wherein the immunoglobulin heavy chains are included in an IgG1 antibody, antibody fragment, or antibody derivative that
30 specifically binds the antigen.

Clause 33. The method of clause 30, 31, or 31a, wherein the immunoglobulin heavy chains are included in an IgG2a antibody, antibody fragment, or antibody derivative that specifically binds the antigen.

5 Clause 34. The method of clause 30, 31, or 31a, wherein the immunoglobulin heavy chains are included in an IgG2b antibody, antibody fragment, or antibody derivative that specifically binds the antigen.

Clause 35. The method of clause 30, 31, or 31a, wherein the immunoglobulin heavy
10 chains are included in an IgM antibody, antibody fragment, or antibody derivative that specifically binds the antigen.

Clause 36. An antibody or immunoglobulin heavy chain isolated in the method of any one of clauses 28 to 35, or a antigen-binding fragment or derivative of the antibody or
15 heavy chain.

Clause 37. A pharmaceutical composition comprising the antibody, antibody
fragment, or antibody derivative of clause 36 and a pharmaceutically acceptable carrier,
excipient, or diluent.

20

Clause 38. A method for isolating splenic tissue comprising providing the mouse of 1
to 27,

collecting a spleen or portion thereof from the mouse, and

obtaining tissue from the spleen or portion.

25

Clause 39. The method of clause 38, further comprising isolating at least one
antigen-specific B-cell from the splenic tissue, wherein the B-cell expresses a heavy
chain containing a human variable region.

30 Clause 40. The method of clause 38 or 39, wherein a step of immunizing the mouse
with an antigen is performed before the step of collecting a spleen from the mouse.

Clause 41. The method of clause 40, wherein the antigen is a human antigen.

35 Clause 42. The method of clause 40 or 41 wherein the at least one antigen-specific
B-cell produces an IgG1, IgG2a, IgG2b or IgM antibody comprising said heavy chain,
wherein the antibody specifically binds the antigen.

Clause 43. The method of clauses 38 to 42, wherein the at least one antigen-specific B-cell that produces said heavy chain is fused with an immortal myeloma cell to produce a hybridoma cell.

5

Clause 44. The method of clauses 38 to 43, further comprising a step of isolating an immunoglobulin heavy chain from the B-cell or the hybridoma cell.

Clause 45. An antibody or immunoglobulin heavy chain isolated in the method of clause 44, or a antigen-binding fragment or derivative of the antibody or heavy chain.

10

Clause 46. A pharmaceutical composition comprising the antibody, antibody fragment, or antibody derivative of clause 45 and a pharmaceutically acceptable carrier, excipient, or diluent.

15

Clause 47. A method for obtaining a humanised antibody, comprising

selecting a mouse that expresses immunoglobulin heavy chains containing human variable regions,

wherein the mouse comprises a genome that includes an immunoglobulin heavy chain locus comprising human VH, DH, and JH gene segments positioned upstream to a mouse constant region,

20

wherein the mouse expresses immunoglobulin heavy chains, characterized in that at least 90% of the immunoglobulin heavy chains expressed by the mouse are immunoglobulin heavy chains containing a human variable region,

wherein the mouse expresses serum IgG1, IgG2b, and IgM antibodies comprising said heavy chains containing a human variable region,

25

wherein the mouse produces a normal proportion of mature splenic B-cells,

wherein the mouse produces a normal proportion of bone marrow B-cell progenitor cells, and

wherein the mouse expresses a normal proportion of IgG1, IgG2a, IgG2b, and IgM in a sample of serum obtained from the mouse, and

30

wherein each said normal proportion is a proportion produced by a mouse that expresses immunoglobulin heavy chains containing mouse variable regions and does not express immunoglobulin heavy chains containing human variable regions;

collecting serum from said mouse; and

5 obtaining a pool of humanised antibodies comprising IgG1, IgG2b, and IgM antibodies from the serum.

Clause 48. The method of clause 47, comprising a step of immunizing the mouse with an antigen before the step of collecting serum from said mouse.

10 Clause 49. The method of clause 48, further comprising steps of contacting said pool of humanised antibodies with said antigen; binding said antigen with a humanised antibody in said pool of humanised antibodies; and

isolating the humanised antibody that binds to said antigen.

15

Clause 50. The method of clause 49, further comprising steps of

contacting the humanised antibody that binds to said antigen with an isotype-specific antibody, wherein the isotype-specific antibody recognizes IgG1, IgG2a, IgG2b, or IgM; and

20 isolating the humanised antibody that binds to said isotype-specific antibody.

Clause 51. The method of clause 48, further comprising the steps of collecting the spleen or tissue thereof from said mouse, isolating B-cells from splenic tissue, fusing said B-cells with immortal myeloma cells to produce hybridoma cells
25 expressing a pool of humanised antibodies comprising IgG antibodies from the serum, wherein the pool of antibodies is used in the method of clause 48.

Clause 52. The method of any of clauses 47-51, wherein said selected mouse comprises mouse immunoglobulin heavy chain V, D and J gene segments which are
30 positioned in said mouse heavy chain immunoglobulin locus in an orientation that is inverted relative to its natural endogenous orientation.

Clause 53. The method of any of clauses 47-52 wherein the mouse expresses Ig subtypes in a relative proportion of

- 5
- (i) serum IgG1 at a concentration of about 25-350 µg/ml;
 - (ii) serum IgG2a at a concentration of about 0-200 µg/ml;
 - (iii) serum IgG2b at a concentration of about 30-800 µg/ml; and
 - (iv) serum IgM at a concentration of about 50-300 µg/ml;

Or

- 10
- (i) serum IgG1 at a concentration of about 10-600 µg/ml;
 - (ii) serum IgG2a at a concentration of about 0-500 µg/ml;
 - (iii) serum IgG2b at a concentration of about 20-700 µg/ml; and
 - (iv) serum IgM at a concentration of about 50-700 µg/ml;

15 as determined by immunoglobulin capture on a plate followed by incubation with an anti-mouse isotype-specific antibodies each comprising a label and quantification of each immunoglobulin based on the level of each label.

Clause 54. The method of any one of clauses 47 to 53, wherein, at least 95, 96, 97, 98, 99, or 99.5% of the immunoglobulin heavy chains expressed by the mouse are immunoglobulin heavy chains comprising human variable regions.

20 Clause 55. The method of any clauses 47-54, wherein a mouse immunoglobulin heavy chain enhancer is positioned in said mouse heavy chain immunoglobulin locus between the human VH, DH, and JH gene segments and the mouse constant region.

Clause 56. The method of any of clauses 47-55, wherein a mouse S-mu switch is positioned in said mouse heavy chain immunoglobulin locus between the human VH, 25 DH, and JH gene segments and the mouse constant region.

Clause 57. The method of any of clauses 47-56, wherein endogenous mouse immunoglobulin heavy chain V, D and J gene segments are positioned in said mouse heavy chain immunoglobulin locus upstream to the human VH, DH, and JH gene segments.

Clause 58. The method of clause 57, wherein the mouse immunoglobulin heavy chain V, D and J gene segments are present in said mouse heavy chain immunoglobulin locus with endogenous inter-gene segment sequences.

Clause 59. The method of clause 57 or 58, wherein the mouse immunoglobulin heavy chain V, D and J gene segments are positioned in said mouse heavy chain immunoglobulin locus in an orientation that is inverted relative to its natural endogenous orientation.

Clause 60. The method of any of clauses 47-59, wherein the mouse expresses light chains containing human kappa variable regions.

Clause 61. The method of clause 60, wherein the mouse expresses immunoglobulin light chains containing human Jk.

Clause 62. The method of any of clauses 47-51, wherein the mouse expresses light chains containing human lambda variable regions.

Clause 63. The method of clause 62, wherein the mouse expresses immunoglobulin light chains containing human Jλ.

Clause 64. The method of clause 61, comprising a genome that includes human Vk and Jk gene segments positioned in said mouse heavy chain immunoglobulin locus upstream to a mouse CL.

Clause 65. The mouse of clause 64, wherein the mouse CL is an endogenous Cκ.

Clause 66. The mouse of clauses 64 or 65, wherein the human Vk and Jk gene segments comprise Vk2-24, Vk3-20, Vk1-17, Vk1-16, Vk3-15, Vk1-13, Vk1-12, Vk3-11, Vk1-9, Vk1-8, Vk1-6, Vk1-5, Vk5-2, Vk4-1, Jk1, Jk2, Jk3, Jk4 and Jk5.

Clause 67. The method of any of clauses 47-51, wherein the human VH, DH and JH gene segments contain

human VH gene segments: VH2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1;

human DH gene segments: D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and

human JH gene segments: J1, J2, J3, J4, J5 and J6.

Non-Human Vertebrates Expressing Kappa & Lambda Variable Regions

5 (i) K and L Chains Produced in Human-Like Ratios

This aspect of the invention is useful for producing light chains that are not skewed to non-human-like ratios. For example, in mice kappa-type light chains predominate by far over lambda-type light chains (typically of the order of 95% kappa light chains : 5% lambda light chains in a wild-type mouse). Humans, on the other hand, typically display
10 around 60% kappa : around 40% lambda. Thus, lambda expression is much higher than found in a mouse. It would be desirable to provide a non-human vertebrate, such as a mouse or a rat, in which a higher proportion of lambda-type light chains can be expressed. This is useful when the vertebrate expresses light chains bearing human lambda variable regions and other light chains bearing human kappa variable regions.
15 To this end, the inventors have demonstrated for the first time such a vertebrate that expresses elevated lambda light chains, and thus the invention provides:-

A non-human vertebrate (eg, a mouse or rat) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments
20 provided by insertion into an endogenous light chain locus of the vertebrate upstream of a constant region, the genome comprising human V κ and J κ gene segments provided by insertion into an endogenous light chain locus of the vertebrate upstream of a constant region, wherein the vertebrate expresses immunoglobulin light chains comprising kappa light chain variable regions and immunoglobulin light chains comprising lambda light
25 chain variable regions, wherein more than 20% of the light chains expressed by the vertebrate comprise lambda variable regions (eg, as determined by FACS of splenic B cells).

The remaining light chains express kappa variable regions.

WO03047336 teaches the desirability of producing human-like kappa:lambda ratios, but
30 this does not provide an enabled or plausible disclosure of how to achieve this.

(ii) K and L Chains Produced with Normal B-Cell Compartments

The inventors have successfully generated non-human vertebrates containing targeted insertion of human V and J lambda gene segments to enable expression of light chains comprising human lambda variable regions by normal (ie, comparable to wild-type vertebrate) B-cell compartments. Thus, the inventors have provided such vertebrates that can usefully produce such light chains with good repertoires and more reliably than prior art transgenic non-human vertebrates that display comprised B-cell compartments of reduced size and maturity, and indeed which may not even produce light chains having human lambda variable regions. Thus, the invention provides:-

A non-human vertebrate (eg, a mouse or rat) whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments provided by insertion into an endogenous light chain locus of the vertebrate upstream of a constant region, the genome comprising human V κ and J κ gene segments provided by insertion into an endogenous light chain locus of the vertebrate upstream of a constant region, wherein the vertebrate expresses immunoglobulin light chains comprising kappa light chain variable regions and immunoglobulin light chains comprising lambda light chain variable regions, and wherein the vertebrate produces a normal proportion or percentage of mature splenic B-cells (eg, as determined by FACS of splenic B cells).

With regard to non-human vertebrates (i) and (ii), the following embodiments are contemplated (unless specified, each embodiment applies to (i) or (ii)):-

In an embodiment, the human V λ and J λ insertion comprises at least the functional human V and J gene segments comprised by a human lambda chain Ig locus from V λ 3-27 to C λ 7.

In an embodiment, the human V λ and J λ insertion comprises at least human V gene segments V λ 3-27, V λ 3-25, V λ 2-23, V λ 3-22, V λ 3-21, V λ 3-19, V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8, V λ 4-3 and V λ 3-1, optionally the alleles of Table 18.

In an embodiment, the human V λ and J λ insertion comprises one, more or all of human J gene segments J λ 1, J λ 2, J λ 3, J λ 6 and J λ 7.

In an embodiment, the human V λ and J λ insertion comprises an insertion of a human J λ -C λ cluster, wherein the cluster comprises the J and C gene segments from J λ 1 to C λ 7.

In an embodiment, the human V λ and J λ insertion comprises an insertion of a human E λ enhancer. For example, the E λ enhancer is provided in germline configuration with respect to a human J λ 7 that is also comprised by the insertion. For example, the E λ enhancer is provided in germline configuration with respect to a human J λ -C λ cluster that is also comprised by the insertion, wherein the cluster comprises J λ 1 to C λ 7 in human germline configuration. In a human germline configuration the E λ enhancer is 3' of the J λ -C λ cluster.

In an embodiment or vertebrate (i) or (ii), the human V λ and J λ insertion is provided by an insertion of a sequence corresponding to coordinates 22886217 to 23327884 of human chromosome 22.

In an embodiment or vertebrate (ii), the human V λ and J λ insertion is provided by an insertion of a sequence corresponding to coordinates 23064876 to 23327884 of human chromosome 22.

In an embodiment, the human V κ and J κ insertion comprises at least the functional human V and J gene segments comprised by a human kappa chain Ig locus from V κ 1-33 to J κ 5.

In an embodiment, the human V κ and J κ insertion comprises at least human V gene segments V κ 1-33, V κ 2-30, V κ 2-29, V κ 2-28, V κ 1-27, V κ 2-24, V κ 3-20, V κ 1-17, V κ 1-16, V κ 3-15, V κ 1-13, V κ 1-12, V κ 3-11, V κ 1-9, V κ 1-8, V κ 1-6, V κ 1-5, V κ 5-2 and V κ 4-1, optionally the alleles of Table 12.

In an embodiment, the human V κ and J κ insertion comprises one, more or all of human J gene segments J κ 1, J κ 2, J κ 3, J κ 4 and J κ 5, optionally the alleles of Table 12.

In an embodiment, more than 30, 35, 40, 45 or 50% of the light chains expressed by the vertebrate comprise lambda variable regions.

In an embodiment, from 20 to 40, 45 or 50% of the light chains expressed by the vertebrate comprise lambda variable regions. In an embodiment, from 30 to 40, 45 or 50% of the light chains expressed by the vertebrate comprise lambda variable regions.

In an embodiment, said kappa light chain variable regions are human kappa light chain variable regions.

In an embodiment, the human V κ and J κ gene segments are in an endogenous kappa light chain locus of the vertebrate upstream of a kappa constant region.

In an embodiment, the human V λ and J λ gene segments are in an endogenous kappa light chain locus of the vertebrate.

In an embodiment, the human V λ and J λ gene segments are in an endogenous lambda light chain locus of the vertebrate.

- 5 In an embodiment, the vertebrate expresses light chains comprising human kappa variable regions and expresses light chains comprising human lambda variable regions. In an example, endogenous (non-human vertebrate) kappa chain expression is substantially inactive or is inactive and/or endogenous (non-human vertebrate) lambda chain expression is substantially inactive or is inactive. Where the vertebrate is a
- 10 mouse, mouse lambda chain expression is typically very low (around 5% or less) and in this case it may not be necessary to engineer the mouse genome to further inactivate endogenous lambda chain expression. Thus, where the vertebrate is a mouse, endogenous kappa chain expression is substantially inactive or is inactive and mouse lambda chain expression is 5% or less of all light chain expression.

- 15 In an embodiment, the vertebrate produces a normal proportion or percentage of mature splenic B-cells. For example, this can be determined by FACS of splenic B cells isolated from the vertebrate.

- In an embodiment, the vertebrate produces a normal ratio of T1, T2 and mature splenic B-cells. For example, this can be determined by FACS of splenic B cells isolated from
- 20 the vertebrate.

In an embodiment, at least 40, 50, 60 or 70 % of total splenic B-cells produced by the vertebrate are mature B-cells. For example, this can be determined by FACS of splenic B cells isolated from the vertebrate.

Further Statements of Invention

- 25 In one embodiment the invention relates to the following:

- A non-human vertebrate (eg, a mouse or rat) or vertebrate cell whose genome comprises human VH, D and JH gene segments upstream of a constant region at a heavy chain locus and/or human VL and JL gene segments upstream of a constant region at a light chain locus, wherein the gene segments are operably linked to the
- 30 constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin heavy and/or light chains comprising human VH and VL domains respectively, wherein the heavy chain locus comprises a human VH gene segment

capable of recombining with a human D and JH gene segment to produce a VH domain, wherein the light chain locus comprises a human VL gene segment capable of recombining with a human JL gene segment to produce a VL domain, or wherein the cell can develop into a vertebrate that expresses said heavy and light chain variable domains.

A non-human vertebrate (eg, a mouse or rat) or vertebrate cell whose genome comprises human VH, D and JH gene segments upstream of a constant region at a heavy chain locus, wherein the gene segments are operably linked to the constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin heavy chains comprising human VH domains, wherein the heavy chain locus comprises a human 01 allele VH gene segment capable of recombining with a human D and JH gene segment to produce a VH domain, or wherein the cell can develop into a vertebrate that expresses said heavy chain variable domain.

A non-human vertebrate (eg, a mouse or rat) or vertebrate cell whose genome comprises VL and JL gene segments upstream of a constant region at a light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin light chains comprising human VL domains, wherein the light chain locus comprises a human 01 allele VL gene segment capable of recombining with a human JL gene segment to produce a VL domain, or wherein the cell can develop into a vertebrate that expresses said light chain variable domain.

Optionally the vertebrate or cell has a genome comprising the heavy chain locus and the light chain locus defined above and therefore comprises a heavy chain locus comprising a human 01 allele VH gene segment capable of recombining with a human D and JH gene segment to produce a VH domain and a light chain locus comprising a human 01 allele VL gene segment capable of recombining with a human JL gene segment to produce a VL domain.

In an alternative embodiment, the invention relates to a non-human vertebrate or vertebrate cell (e.g. a mouse cell or rat cell) whose genome comprises one or more human VH gene segments, one or more human JH gene segments and one or more human D gene segments upstream of a constant region at a heavy chain, wherein the gene segments are operably linked to the constant region thereof so that the cell or vertebrate is capable of producing an antibody heavy chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain, wherein said one or

more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01, VH3-20*d01 and VH3-9*01.

5 In an embodiment of the invention, the VH gene segments are selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01.

For embodiments of the invention, which, for example, define human heavy chain gene segments only, the light chain locus can comprise rearranged or unrearranged VL and JL gene segments, e.g. a single rearranged VJ (such as a single rearranged Vk1-39/J).
10 Additionally or alternatively the light chain locus can be randomly integrated. In another embodiment the VL and JL segments are upstream of an endogenous constant light gene segment.

In a further alternative embodiment, the invention relates to a non-human vertebrate or vertebrate cell (e.g. a mouse cell or rat cell) whose genome comprises one or more
15 human Jk gene segments and one or more human Vk gene segments upstream of a constant region at a light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the cell or vertebrate is capable of producing an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody light chain, wherein said one or more human Vk gene segments comprise or
20 consist of one, more or all human Vk gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

In an alternative embodiment, the invention relates to a non-human vertebrate (eg, a mouse or rat) or vertebrate cell whose genome comprises human VH, D and JH gene
25 segments upstream of a constant region at a heavy chain locus, wherein the JH gene segments comprise JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and/or JH6*01 or JH6*02 and the gene segments are operably linked to the constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin heavy chains comprising human VH domains, wherein the heavy chain locus comprises a human VH gene
30 segment capable of recombining with a human D and one of said JH gene segments to produce a VH domain, or wherein the cell can develop into a vertebrate that expresses said heavy chain variable domain.

In a preferred embodiment, the JH gene segments are JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and JH6*02. In another embodiment, the JH gene segments are JH1*01, JH2*01, JH3*02, JH4*02, JH5*02 and JH6*01.

5 In one embodiment, the non-human vertebrate further comprises one or more of the VH gene segments and/or one or more of the D gene segments from Table 7. In a further embodiment, the non-human vertebrate further comprises the VH gene segments and D gene segments from Table 3.

A non-human vertebrate (eg, a mouse or rat) or vertebrate cell whose genome comprises VL and JL gene segments upstream of a constant region at a light chain
10 locus, wherein the JL gene segments comprise Jk1*01, Jk2*01, Jk3*01, Jk4*01 and/or Jk5*01 and the gene segments are operably linked to the constant region thereof so that the vertebrate or cell is capable of expressing immunoglobulin light chains comprising human VL domains, wherein the light chain locus comprises a human VL gene segment capable of recombining with one of said human JL gene segments to produce a VL
15 domain, or wherein the cell can develop into a vertebrate that expresses said light chain variable domain.

In one embodiment, the non-human vertebrate further comprises one or more or all Vk gene segments from Table 12. In a further embodiment, the non-human vertebrate further comprises the Vk gene segments from Table 10 or 11.

20 Optionally the vertebrate or cell has a genome comprising the heavy chain locus and the light chain locus defined above and therefore comprises a heavy chain locus comprising a human VH gene segment capable of recombining with a human D and one of said JH gene segments to produce a VH domain and a light chain locus comprising a human VL gene segment capable of recombining with one of said human JL gene segments to
25 produce a VL domain.

It is envisaged that in all embodiments of the invention, the genome of the cell or vertebrate in accordance with the invention may not comprise a second human allele of one, more or all of the human gene segment(s).

In all embodiments of the invention, the human JH gene segments, D gene segments
30 and VH gene segments can be upstream of a constant region at an endogenous heavy chain locus and/or the human Jk gene segments and Vk gene segments can be upstream of a constant region at an endogenous light chain locus.

In one embodiment, the endogenous light chain locus is the endogenous kappa locus, and in another embodiment it is the endogenous lambda locus.

Allele combinations

In one embodiment, the allele of the gene segment is a d01 allele, optionally a d01 allele
5 disclosed in Table 7, Table 12 or Table 18.

In one embodiment, vertebrate or cell has a genome further comprising a 02, 03, 04, 05, 10, 12, 18 or d03 allele disclosed in Table 7, Table 12 or Table 18.

The preferred alleles of the invention are set out in Tables 1 to 18 as follows:

Table 1: IgH Alleles #1 – S1 alleles

	Allele
J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02
J _H 2	01
J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01

D2-21	02
D1-20	01
D6-19	01
D5-18	01
D4-17	01
D3-16	02
D2-15	01
D1-14	01
D6-13	01
D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02
D1-1	01
V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10

In an alternative Table 1, the JH6 allele can be JH6*01.

Table 2: IgH Alleles #2 – S2 alleles

	ID
J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02
J _H 2	01
J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01
D2-21	02
D1-20	01
D6-19	01
D5-18	01
D4-17	01
D3-16	02

D2-15	01
D1-14	01
D6-13	01
D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02
D1-1	01
V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10
V _H 3-7	01
V _H 1-8	01
V _H 3-9	01
V _H 3- 11	01
V _H 3-	01

13	
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In an alternative Table 2, the JH6 allele can be JH6*01.

Table 3: IgH Alleles #3 – S3 alleles

ID	Allele
J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02
J _H 2	01
J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01
D2-21	02
D1-20	01
D6-19	01
D5-18	01

D4-17	01
D3-16	02
D2-15	01
D1-14	01
D6-13	01
D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02
D1-1	01
V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10
V _H 3-7	01
V _H 1-8	01
V _H 3-9	01
V _H 3-11	01

V _H 3- 13	01
V _H 3- 15	01
V _H 1- 18	01
V _H 3- 20	01 or d01
V _H 3- 21	01 or 03
V _H 3- 23	04
V _H 1- 24	01 or d01
V _H 2- 26	01 or d01

In an alternative Table 3, the JH6 allele can be JH6*01.

Table 4: IgH Alleles #4 – S4 alleles

ID	Allele
J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02

J _H 2	01
J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01
D2-21	02
D1-20	01
D6-19	01
D5-18	01
D4-17	01
D3-16	02
D2-15	01
D1-14	01
D6-13	01
D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02

D1-1	01
V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10
V _H 3-7	01
V _H 1-8	01
V _H 3-9	01
V _H 3-11	01
V _H 3-13	01
V _H 3-15	01
V _H 1-18	01
V _H 3-20	01 or d01
V _H 3-21	01 or 03
V _H 3-23	04
V _H 1-	01 or d01

24	
V _H 2- 26	01 or d01
V _H 4- 28	05
V _H 3- 30	18
V _H 4- 31	03
V _H 3- 33	01
V _H 4- 34	01
V _H 4- 39	01

In an alternative Table 4, the JH6 allele can be JH6*01.

Table 5: IgH Alleles #5 – S5 alleles

ID	Allele
J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02
J _H 2	01

J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01
D2-21	02
D1-20	01
D6-19	01
D5-18	01
D4-17	01
D3-16	02
D2-15	01
D1-14	01
D6-13	01
D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02
D1-1	01

V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10
V _H 3-7	01
V _H 1-8	01
V _H 3-9	01
V _H 3-11	01
V _H 3-13	01
V _H 3-15	01
V _H 1-18	01
V _H 3-20	01 or d01
V _H 3-21	01 or 03
V _H 3-23	04
V _H 1-24	01 or d01

V _H 2- 26	01 or d01
V _H 4- 28	05
V _H 3- 30	18
V _H 4- 31	03
V _H 3- 33	01
V _H 4- 34	01
V _H 4- 39	01
V _H 3- 43	01
V _H 1- 45	02
V _H 1- 46	01
V _H 3- 48	01

In an alternative Table 5, the JH6 allele can be JH6*01.

Table 6: IgH Alleles #6 – S6 alleles

ID	Allele
----	--------

J _H 6	02
J _H 5	02
J _H 4	02
J _H 3	02
J _H 2	01
J _H 1	01
D7-27	02
D1-26	01
D6-25	01
D5-24	01
D4-23	01
D3-22	01
D2-21	02
D1-20	01
D6-19	01
D5-18	01
D4-17	01
D3-16	02
D2-15	01
D1-14	01
D6-13	01

D5-12	01
D4-11	01
D3-10	01
D3-9	01
D2-2	02
D1-1	01
V _H 6-1	01
V _H 1-2	02 or 04
V _H 1-3	01
V _H 4-4	02
V _H 7-4	01
V _H 2-5	01 or 10
V _H 3-7	01
V _H 1-8	01
V _H 3-9	01
V _H 3-11	01
V _H 3-13	01
V _H 3-15	01
V _H 1-18	01

V _H 3- 20	01 or d01
V _H 3- 21	01 or 03
V _H 3- 23	04
V _H 1- 24	01 or d01
V _H 2- 26	01 or d01
V _H 4- 28	05
V _H 3- 30	18
V _H 4- 31	03
V _H 3- 33	01
V _H 4- 34	01
V _H 4- 39	01
V _H 3- 43	01
V _H 1- 45	02
V _H 1-	01

46	
V _H 3- 48	01
V _H 3- 49	05
V _H 5- 51	01
V _H 3- 53	01
V _H 1- 58	01
V _H 4- 59	01 or 05
V _H 4- 61	01
V _H 3- 64	02
V _H 3- 66	03
V _H 1- 69	12

In an alternative Table 6, the JH6 allele can be JH6*01.

Table 7: IgH Alleles #7 – S7 alleles (a complete repertoire of functional IgH gene segments)

	ID	Allele

1	J _H 6	02
2	J _H 5	02
3	J _H 4	02
4	J _H 3	02
5	J _H 2	01
6	J _H 1	01
7	D7-27	02
8	D1-26	01
9	D6-25	01
10	D5-24	01
11	D4-23	01
12	D3-22	01
13	D2-21	02
14	D1-20	01
15	D6-19	01
16	D5-18	01
17	D4-17	01
18	D3-16	02
19	D2-15	01
20	D1-14	01
21	D6-13	01
22	D5-12	01

23	D4-11	01
24	D3-10	01
25	D3-9	01
26	D2-2	02
27	D1-1	01
28	V _H 6-1	01
29	V _H 1-2	02 or 04
30	V _H 1-3	01
31	V _H 4-4	02
32	V _H 7-4	01
33	V _H 2-5	01 or 10
34	V _H 3-7	01
35	V _H 1-8	01
36	V _H 3-9	01
37	V _H 3-11	01
38	V _H 3-13	01
39	V _H 3-15	1.1 01
40	V _H 1-18	01
41	V _H 3-20	01 or d01

42	V _H 3- 21	01 or 03
43	V _H 3- 23	04
44	V _H 1- 24	01 or d01
45	V _H 2- 26	01 or d01
46	V _H 4- 28	05
47	V _H 3- 30	18
48	V _H 4- 31	03
49	V _H 3- 33	01
50	V _H 4- 34	01
51	V _H 4- 39	01
52	V _H 3- 43	01
53	V _H 1- 45	02
54	V _H 1- 46	01
55	V _H 3-	01

	48	
56	V _H 3- 49	05
57	V _H 5- 51	01
58	V _H 3- 53	01
59	V _H 1- 58	01
60	V _H 4- 59	01 or 05
61	V _H 4- 61	01
62	V _H 3- 64	02
63	V _H 3- 66	03
64	V _H 1- 69	12
65	V _H 2- 70	04
66	V _H 3- 72	01
67	V _H 3- 73	02
68	V _H 3- 74	01

In an alternative Table 7, the JH6 allele can be JH6*01.

Table 8: Igk Alleles #1 – K1 alleles

ID	Allele
Jk5	01
Jk4	01
Jk3	01
Jk2	01 or 04
Jk1	01
Vk4-1	01
Vk5-2	01 or d01
Vk1-5	03
Vk1-6	01
Vk1-8	01
Vk1-9	01 or d01

Table 9: Igk Alleles #2 – K2 alleles

1.2	ID	Allele
	Jk5	01

Jκ4	01
Jκ3	01
Jκ2	01 or 04
Jκ1	01
Vκ4-1	01
Vκ5-2	01 or d01
Vκ1-5	03
Vκ1-6	01
Vκ1-8	01
Vκ1-9	01 or d01
Vκ3-11	01
Vκ1-12	01
Vκ1-13	01
Vκ3-15	01
Vκ1-16	02
Vκ1-17	01
Vκ3-20	01
Vκ6-21	01
Vκ2-24	01

Table 10: Igκ Alleles #3 – K3 alleles

1.3	ID	Allele
	Jk5	01
	Jk4	01
	Jk3	01
	Jk2	01 or 04
	Jk1	01
	Vk4-1	01
	Vk5-2	01 or d01
	Vk1-5	03
	Vk1-6	01
	Vk1-8	01
	Vk1-9	01 or d01
	Vk3-11	01
	Vk1-12	01
	Vk1-13	01
	Vk3-15	01
	Vk1-16	02
	Vk1-17	01
	Vk3-20	01
	Vk6-21	01

Vκ2-24	01
Vκ1-27	01
Vκ2-28	01
Vκ2-29	01
Vκ2-30	01
Vκ1-33	01
Vκ1D-39	01
Vκ2D-40	01

Table 11: Igκ Alleles #4 – K4 alleles

1.4	ID	Allele
Jκ5	01	
Jκ4	01	
Jκ3	01	
Jκ2	01 or 04	
Jκ1	01	
Vκ4-1	01	
Vκ5-2	01 or d01	
Vκ1-5	03	

Vκ1-6	01
Vκ1-8	01
Vκ1-9	01 or d01
Vκ3-11	01
Vκ1-12	01
Vκ1-13	01
Vκ3-15	01
Vκ1-16	02
Vκ1-17	01
Vκ3-20	01
Vκ6-21	01
Vκ2-24	01
Vκ1-27	01
Vκ2-28	01
Vκ2-29	01
Vκ2-30	01
Vκ1-33	01
Vκ1D-39	01
Vκ2D-40	01
Vκ3D-7	01
Vκ1D-8	01 or d01
Vκ1D-43	01

Vκ3D-11	01 or d01
Vκ1D-12	02
Vκ1D-13	d01
Vκ3D-15	d01
Vκ1D-16	01
Vκ1D-17	01
Vκ3D-20	01

Table 12: Igκ Alleles #5 – K5 alleles (a complete repertoire of functional human kappa gene segments)

1.5	ID	Allele
Jκ5		01
Jκ4		01
Jκ3		01
Jκ2		01 or 04
Jκ1		01
Vκ4-1		01
Vκ5-2		01 or d01
Vκ1-5		03
Vκ1-6		01

Vк1-8	01
Vк1-9	01 or d01
Vк3-11	01
Vк1-12	01
Vк1-13	01
Vк3-15	01
Vк1-16	02
Vк1-17	01
Vк3-20	01
Vк6-21	01
Vк2-24	01
Vк1-27	01
Vк2-28	01
Vк2-29	01
Vк2-30	01
Vк1-33	01
Vк1D-39	01
Vк2D-40	01
Vк3D-7	01
Vк1D-8	01 or d01
Vк1D-43	01
Vк3D-11	01 or d01

Vκ1D-12	02
Vκ1D-13	d01
Vκ3D-15	d01
Vκ1D-16	01
Vκ1D-17	01
Vκ3D-20	01
Vκ2D-26	01 or d01
Vκ2D-28	01 or d01
Vκ2D-29	01
Vκ2D-30	01
Vκ1D-33	01
Vκ1D-39	01

In one aspect of Table 12 there no Vκ1D-39 gene segment present in the genome.

For the avoidance of doubt, any reference to Table 12 herein, including in the claims,
can be read with or without the limitation that in one aspect of Table 12, there no Vκ1D-
5 39 gene segment present in the genome.

In an alternative Table 12, the Vκ2D-26 allele is Vκ2D-26*d02.

Table 13: Igλ Alleles #1 - L1 or P1 Alleles

ID	Allele

Cλ7	01
Jλ7	01
Cλ6	04
Jλ6	01
Cλ3	03
Jλ3	02
Cλ2	02
Jλ2	01
Cλ1	02
Jλ1	01
Vλ3-1	01

Table 14: Igλ Alleles #2 - L2 or P2 Alleles

ID	Allele
Cλ7	01
Jλ7	01
Cλ6	04
Jλ6	01
Cλ3	03
Jλ3	02

Cλ2	02
Jλ2	01
Cλ1	02
Jλ1	01
Vλ3-1	01
Vλ4-3	01
Vλ2-8	01
Vλ3-9	01
Vλ3-10	01
Vλ2-11	01
Vλ3-12	02
Vλ2-14	01
Vλ3-16	01
Vλ2-18	01

Table 15: Igλ Alleles #3 - L3 or P3 Alleles

ID	Allele
Cλ7	01
Jλ7	01
Cλ6	04

Jλ6	01
Cλ3	03
Jλ3	02
Cλ2	02
Jλ2	01
Cλ1	02
Jλ1	01
Vλ3-1	01
Vλ4-3	01
Vλ2-8	01
Vλ3-9	01
Vλ3-10	01
Vλ2-11	01
Vλ3-12	02
Vλ2-14	01
Vλ3-16	01
Vλ2-18	01
Vλ3-19	01
Vλ3-21	01 or d01
Vλ3-22	01
Vλ2-23	02 or d02
Vλ3-25	01 or d03

Vλ3-27	01
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Table 16: Igλ Alleles #4 - L4 or P4 Alleles

ID	Allele
Cλ7	01
Jλ7	01
Cλ6	04
Jλ6	01
Cλ3	03
Jλ3	02
Cλ2	02
Jλ2	01
Cλ1	02
Jλ1	01
Vλ3-1	01
Vλ4-3	01
Vλ2-8	01
Vλ3-9	01
Vλ3-10	01
Vλ2-11	01

Vλ3-12	02
Vλ2-14	01
Vλ3-16	01
Vλ2-18	01
Vλ3-19	01
Vλ3-21	01 or d01
Vλ3-22	01
Vλ2-23	02 or d02
Vλ3-25	01 or d03
Vλ3-27	01
Vλ1-36	01
Vλ5-37	01
Vλ5-39	01
Vλ1-40	01
Vλ7-43	01
Vλ1-44	01
Vλ5-45	03
Vλ7-46	01

Table 17: Igλ Alleles #5 - L5 or P5 Alleles

ID	Allele
----	--------

Cλ7	01
Jλ7	01
Cλ6	04
Jλ6	01
Cλ3	03
Jλ3	02
Cλ2	02
Jλ2	01
Cλ1	02
Jλ1	01
Vλ3-1	01
Vλ4-3	01
Vλ2-8	01
Vλ3-9	01
Vλ3-10	01
Vλ2-11	01
Vλ3-12	02
Vλ2-14	01
Vλ3-16	01
Vλ2-18	01
Vλ3-19	01

Vλ3-21	01 or d01
Vλ3-22	01
Vλ2-23	02 or d02
Vλ3-25	01 or d03
Vλ3-27	01
Vλ1-36	01
Vλ5-37	01
Vλ5-39	01
Vλ1-40	01
Vλ7-43	01
Vλ1-44	01
Vλ5-45	03
Vλ7-46	01
Vλ1-47	01
Vλ9-49	01
Vλ1-51	01
Vλ5-52	01
Vλ10-54	02

Table 18: Igλ Alleles #6 - L6 or P6 Alleles (a complete repertoire of functional human lambda alleles)

1.6	ID	Allele
	Cλ7	01
	Jλ7	01
	Cλ6	04
	Jλ6	01
	Cλ3	03
	Jλ3	02
	Cλ2	02
	Jλ2	01
	Cλ1	02
	Jλ1	01
	Vλ3-1	01
	Vλ4-3	01
	Vλ2-8	01
	Vλ3-9	01
	Vλ3-10	01
	Vλ2-11	01
	Vλ3-12	02
	Vλ2-14	01
	Vλ3-16	01

Vλ2-18	01
Vλ3-19	01
Vλ3-21	d01
Vλ3-22	01
Vλ2-23	02 or d02
Vλ3-25	01or d03
Vλ3-27	01
Vλ1-36	01
Vλ5-37	01
Vλ5-39	01
Vλ1-40	01
Vλ7-43	01
Vλ1-44	01
Vλ5-45	03
Vλ7-46	01
Vλ1-47	01
Vλ9-49	01
Vλ1-51	01
Vλ5-52	01
Vλ10-54	02
Vλ6-57	01
Vλ4-60	03 or d03

Vλ8-61	01
Vλ4-69	01

With respect to Table 18, in one aspect there is no Cλ6 or Jλ6 gene segment present in the genome. In another aspect, additionally or alternatively, there is no Vλ3-22 and/or Vλ5-39 and/or Vλ10-54 gene segment.

- 5 For the avoidance of doubt, any reference to Table 18 herein, including in the claims, can be read with or without the limitation that, in one aspect of Table 18, there no Cλ6 or Jλ6 present, and without or without the limitation that there is no Vλ3-22 and/or Vλ5-39 and/or Vλ10-54 gene segment.

- 10 The disclosure of WO2013/041844 is incorporated herein by reference. The examples of gene segments in WO2013/041844 are specifically incorporated herein as though specifically and explicitly disclosed herein as possible gene segments with respect to the present invention and for possible inclusion in one or more claims herein.

- Each aspect, embodiment, clause or provision described herein can be combined in a non-human vertebrate capable of expressing one or more human gene segments
15 disclosed in WO2013/041844 and/or described herein or a binding site or antibody that is a product of recombination of one or more human gene segments disclosed in WO2013/041844 and/or described herein, as appropriate,

- The gene segments disclosed in Tables 1-7 of WO2013/041844 are specifically and explicitly disclosed herein as possible gene segment sequences with respect to the
20 present invention and for possible inclusion in one or more claims herein. The sequences are set out in the sequence listing filed with that application.

Further examples of sequences of gene segments for use in the context of the invention are set out in the sequences included at the end of the description.

- In a preferred embodiment, the genome of the vertebrate or cell of the invention
25 comprises one or more gene segments from any one of Tables 1 to 18. In a further preferred embodiment, the genome of the vertebrate or cell of the invention comprises a combination of any two gene segments from any one of Tables 1 to 18. In a yet further preferred embodiment, the genome of the vertebrate or cell of the invention comprises a combination of any three gene segments from any one of Tables 1 to 18.

In the most preferred embodiment, the genome of the vertebrate or cell of the invention comprises a combination of any four gene segments from any one of Tables 1 to 18. Preferably a VH and a JH heavy chain segment is selected from Table 7 and a VL and a JL light chain segment is selected from Table 12 or Table 18. Optionally a D heavy chain segment is selected from Table 7.

The invention further relates to a non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises human VL and JL gene segments upstream of a constant region at an endogenous light chain locus, wherein the vertebrate or cell expresses immunoglobulin light chains comprising human variable regions, or where the cell can develop into a vertebrate that expresses said light chains, wherein said immunoglobulin light chains comprise light chains comprising human variable regions derived from recombination of (i) human Vk and Jk gene segments selected from the group consisting of Vk and Jk gene segments of any one of Tables 8 to 12 or (ii) human Vλ and Jλ gene segments selected from the group consisting of Vλ and Jλ gene segments of any one of Tables 12 to 18.

In one embodiment the vertebrate or cell of the invention expresses light chains comprising human lambda variable regions and wherein at least 60%, 70%, 80%, 85%, 90% or 95% of the variable regions of such light chains are derived from recombination of human Vλ and Jλ gene segments.

Optionally the light chains are expressed as IgG antibodies, for example IgG1 or IgG2b, optionally IgG2a.

The constant region can be a kappa or lambda constant region; optionally human, mouse or rat constant region. Said endogenous light chain locus can be a kappa or lambda locus; optionally wherein the genome comprises at least the V and J gene segments of Table 8 at an endogenous light chain locus, for example the kappa locus and/or at least the V and J gene segments of Table 13 at an endogenous light chain locus, for example the lambda or kappa locus.

Said light chains can comprise immunoglobulin light chains comprising human variable regions that derived from recombination of (ii), each such variable region being expressed with a constant region encoded by a Cλ gene segment selected from the group consisting of the Cλ gene segments of Table 18.

In this embodiment of the invention, the vertebrate or cell can express light chains comprising human lambda variable regions and at least 60%, 70% or 80% of the variable regions of such light chains can be derived from recombination of human V λ and J λ gene segments, for example the V and J segments listed in Table 18.

- 5 A invention also relates to a non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises human VH, D and JH gene segments upstream of a constant region at an endogenous heavy chain locus, wherein the vertebrate or cell expresses immunoglobulin heavy chains comprising human variable regions or the cell can develop into a vertebrate that expresses said heavy chains, or where the cell can express
- 10 immunoglobulin heavy chains comprising human variable regions, wherein said immunoglobulin heavy chains comprise heavy chains comprising human variable regions derived from recombination of (iii) human VH, D and JH gene segments selected from the group consisting of VH, D and JH gene segments of Table 7.

- In one embodiment said light chains are co-expressed with said heavy chains to form
- 15 antibodies, eg, IgG antibodies.

- A non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments
- 20 have been provided by insertion into an endogenous light chain locus of the vertebrate or cell, wherein the vertebrate comprises immunoglobulin light chains comprising lambda variable regions (lambda light chains) or the cell can develop into a vertebrate that expresses said immunoglobulin light chains, wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable regions derived from
- 25 recombination of human V λ and J λ gene segments; wherein at least 60%, 70%, 80% or 90% of the variable regions of the lambda light chains expressed by the vertebrate are derived from recombination of human V λ and J λ gene segments; optionally wherein the vertebrate or cell any vertebrate or cell disclosed herein.

- A variable domain or region derived from, or produced as a result of, recombination of
- 30 human gene segments is also referred to herein as a recombinant of said gene segments.

The gene segments in the heavy and/or light locus are operably linked to the constant region, so that the vertebrate is capable of producing an antibody heavy or light chain produced by recombination of the gene segments.

In one embodiment the cell or non-human vertebrate has a genome comprising the kappa segments of table 8, or table 9 or table 10, table 11 or table 12, or any combination thereof.

- 5 In one embodiment the cell or non-human vertebrate has a genome comprising the lambda segments of table 13 or table 14 or table 15 or table 16 or table 17 or table 18, or any combination thereof.

In one embodiment the cell or non-human vertebrate has a genome comprising the heavy chain segments of table 1 or table 2 or table 3 or table 4 or table 5 or table 6 or table 7 or any combination thereof.

- 10 In one embodiment the cell or non-human vertebrate of the invention can express light chains comprising human variable regions derived from recombination (i.e. recombinants) of (i) human V_K and J_K gene segments selected from the group consisting of V_K and J_K gene segments of Table 8, or table 9, or table 10, or table 11 or table 12, or any combination thereof

- 15 In one embodiment the cell or non-human vertebrate of the invention can express light chains comprising human variable regions derived from recombination (i.e. recombinants) of (ii) human V_λ and J_λ gene segments selected from the group consisting of V_λ and J_λ gene segments of Table 13 or table 14 or table 15 or table 16 or table 17 or table 18, or any combination thereof.

- 20 In one embodiment the cell or vertebrate of the invention can express heavy chains comprising human variable regions derived from recombination (i.e. recombinants) of human V_H, D and J_H gene segments selected from the group consisting of V_H, D and J_H gene segments of table 1 or table 2, or table 3, or table 4 or table 5 or table 6 or table 7, or any combination thereof.

- 25 The invention further includes the following provisions

Provision 1 - The vertebrate or cell of the invention has a genome comprising one or more alleles selected from alleles numbered 1 to 68 in Table 7.

Provision 2 – The vertebrate or cell according to provision 1 comprising allele number 1 from Table 1 and one or more alleles selected from alleles numbered 2 to 68 of Table 7.

Provision 3 – The vertebrate or cell according to any preceding provision comprising allele number 2 from Table 7 and one or more alleles selected from alleles numbered 3 to 68 of Table 7.

5 Provision 4 – The vertebrate or cell according to any preceding provision comprising allele number 3 from Table 7 and one or more alleles selected from alleles numbered 4 to 68 of Table 7.

Provision 5 – The vertebrate or cell according to any preceding provision comprising allele number 4 from Table 7 and one or more alleles selected from alleles numbered 5 to 68 of Table 7.

10 Provision 6 – The vertebrate or cell according to any preceding provision comprising allele number 5 from Table 7 and one or more alleles selected from alleles numbered 6 to 68 of Table 7.

15 Provision 7 – The vertebrate or cell according to any preceding provision comprising allele number 6 from Table 7 and one or more alleles selected from alleles numbered 7 to 68 of Table 7.

Provision 8 – The vertebrate or cell according to any preceding provision comprising allele number 7 from Table 7 and one or more alleles selected from alleles numbered 8 to 68 of Table 7.

20 Provision 9 – The vertebrate or cell according to any preceding provision comprising allele number 8 from Table 7 and one or more alleles selected from alleles numbered 9 to 68 of Table 7.

Provision 10 – The vertebrate or cell according to any preceding provision comprising allele number 9 from Table 7 and one or more alleles selected from alleles numbered 10 to 68 of Table 7.

25 Provision 11 – The vertebrate or cell according to any preceding provision comprising allele number 10 from Table 7 and one or more alleles selected from alleles numbered 11 to 68 of Table 7.

30 Provision 12 – The vertebrate or cell according to any preceding provision comprising allele number 11 from Table 7 and one or more alleles selected from alleles numbered 12 to 68 of Table 7.

Provision 13 – The vertebrate or cell according to any preceding provision comprising allele number 12 from Table 7 and one or more alleles selected from alleles numbered 13 to 68 of Table 7.

5 Provision 14 – The vertebrate or cell according to any preceding provision comprising allele number 13 from Table 7 and one or more alleles selected from alleles numbered 14 to 68 of Table 7.

Provision 15 – The vertebrate or cell according to any preceding provision comprising allele number 14 from Table 7 and one or more alleles selected from alleles numbered 15 to 68 of Table 7.

10 Provision 16 – The vertebrate or cell according to any preceding provision comprising allele number 15 from Table 7 and one or more alleles selected from alleles numbered 16 to 68 of Table 7.

15 Provision 17 – The vertebrate or cell according to any preceding provision comprising allele number 16 from Table 7 and one or more alleles selected from alleles numbered 17 to 68 of Table 7.

Provision 18 – The vertebrate or cell according to any preceding provision comprising allele number 17 from Table 7 and one or more alleles selected from alleles numbered 18 to 68 of Table 7.

20 Provision 19 – The vertebrate or cell according to any preceding provision comprising allele number 18 from Table 7 and one or more alleles selected from alleles numbered 19 to 68 of Table 7.

Provision 20 – The vertebrate or cell according to any preceding provision comprising allele number 19 from Table 7 and one or more alleles selected from alleles numbered 20 to 68 of Table 7.

25 Provision 21 – The vertebrate or cell according to any preceding provision comprising allele number 20 from Table 7 and one or more alleles selected from alleles numbered 21 to 68 of Table 7.

30 Provision 22 – The vertebrate or cell according to any preceding provision comprising allele number 21 from Table 7 and one or more alleles selected from alleles numbered 22 to 68 of Table 7.

Provision 23 – The vertebrate or cell according to any preceding provision comprising allele number 22 from Table 7 and one or more alleles selected from alleles numbered 23 to 68 of Table 7.

5 Provision 24 – The vertebrate or cell according to any preceding provision comprising allele number 23 from Table 7 and one or more alleles selected from alleles numbered 24 to 68 of Table 7.

Provision 25 – The vertebrate or cell according to any preceding provision comprising allele number 24 from Table 7 and one or more alleles selected from alleles numbered 25 to 68 of Table 7.

10 Provision 26 – The vertebrate or cell according to any preceding provision comprising allele number 25 from Table 7 and one or more alleles selected from alleles numbered 26 to 68 of Table 7.

15 Provision 27 – The vertebrate or cell according to any preceding provision comprising allele number 26 from Table 7 and one or more alleles selected from alleles numbered 27 to 68 of Table 7.

Provision 28 – The vertebrate or cell according to any preceding provision comprising allele number 27 from Table 7 and one or more alleles selected from alleles numbered 28 to 68 of Table 7.

20 Provision 29 – The vertebrate or cell according to any preceding provision comprising allele number 28 from Table 7 and one or more alleles selected from alleles numbered 29 to 68 of Table 7.

Provision 30 – The vertebrate or cell according to any preceding provision comprising allele number 29 from Table 7 and one or more alleles selected from alleles numbered 30 to 68 of Table 7.

25 Provision 31 – The vertebrate or cell according to any preceding provision comprising allele number 30 from Table 7 and one or more alleles selected from alleles numbered 31 to 68 of Table 7.

30 Provision 32– The vertebrate or cell according to any preceding provision comprising allele number 31 from Table 7 and one or more alleles selected from alleles numbered 32 to 68 of Table 7.

Provision 33– The vertebrate or cell according to any preceding provision comprising allele number 32 from Table 7 and one or more alleles selected from alleles numbered 33 to 68 of Table 7.

5 Provision 34– The vertebrate or cell according to any preceding provision comprising allele number 33 from Table 7 and one or more alleles selected from alleles numbered 34 to 68 of Table 7.

Provision 35– The vertebrate or cell according to any preceding provision comprising allele number 34 from Table 7 and one or more alleles selected from alleles numbered 35 to 68 of Table 7.

10 Provision 36– The vertebrate or cell according to any preceding provision comprising allele number 35 from Table 7 and one or more alleles selected from alleles numbered 36 to 68 of Table 7.

15 Provision 37– The vertebrate or cell according to any preceding provision comprising allele number 36 from Table 7 and one or more alleles selected from alleles numbered 37 to 68 of Table 7.

Provision 38– The vertebrate or cell according to any preceding provision comprising allele number 37 from Table 7 and one or more alleles selected from alleles numbered 38 to 68 of Table 7.

20 Provision 39– The vertebrate or cell according to any preceding provision comprising allele number 38 from Table 7 and one or more alleles selected from alleles numbered 39 to 68 of Table 7.

Provision 40– The vertebrate or cell according to any preceding provision comprising allele number 39 from Table 7 and one or more alleles selected from alleles numbered 40 to 68 of Table 7.

25 Provision 41– The vertebrate or cell according to any preceding provision comprising allele number 40 from Table 7 and one or more alleles selected from alleles numbered 41 to 68 of Table 7.

30 Provision 42– The vertebrate or cell according to any preceding provision comprising allele number 41 from Table 7 and one or more alleles selected from alleles numbered 42 to 68 of Table 7.

Provision 43– The vertebrate or cell according to any preceding provision comprising allele number 42 from Table 7 and one or more alleles selected from alleles numbered 43 to 68 of Table 7.

5 Provision 44– The vertebrate or cell according to any preceding provision comprising allele number 43 from Table 7 and one or more alleles selected from alleles numbered 44 to 68 of Table 7.

Provision 45– The vertebrate or cell according to any preceding provision comprising allele number 44 from Table 7 and one or more alleles selected from alleles numbered 45 to 68 of Table 7.

10 Provision 46– The vertebrate or cell according to any preceding provision comprising allele number 45 from Table 7 and one or more alleles selected from alleles numbered 46 to 68 of Table 7.

15 Provision 47– The vertebrate or cell according to any preceding provision comprising allele number 46 from Table 7 and one or more alleles selected from alleles numbered 47 to 68 of Table 7.

Provision 48– The vertebrate or cell according to any preceding provision comprising allele number 47 from Table 7 and one or more alleles selected from alleles numbered 48 to 68 of Table 7.

20 Provision 49– The vertebrate or cell according to any preceding provision comprising allele number 48 from Table 7 and one or more alleles selected from alleles numbered 49 to 68 of Table 7.

Provision 50– The vertebrate or cell according to any preceding provision comprising allele number 49 from Table 7 and one or more alleles selected from alleles numbered 50 to 68 of Table 7.

25 Provision 51– The vertebrate or cell according to any preceding provision comprising allele number 50 from Table 7 and one or more alleles selected from alleles numbered 51 to 68 of Table 7.

30 Provision 52– The vertebrate or cell according to any preceding provision comprising allele number 51 from Table 7 and one or more alleles selected from alleles numbered 52 to 68 of Table 7.

Provision 53– The vertebrate or cell according to any preceding provision comprising allele number 52 from Table 7 and one or more alleles selected from alleles numbered 53 to 68 of Table 7.

5 Provision 54– The vertebrate or cell according to any preceding provision comprising allele number 53 from Table 7 and one or more alleles selected from alleles numbered 54 to 68 of Table 7.

Provision 55– The vertebrate or cell according to any preceding provision comprising allele number 54 from Table 7 and one or more alleles selected from alleles numbered 55 to 68 of Table 7.

10 Provision 56– The vertebrate or cell according to any preceding provision comprising allele number 56 from Table 7 and one or more alleles selected from alleles numbered 57 to 68 of Table 7.

15 Provision 57 – The vertebrate or cell according to any preceding provision comprising allele number 57 from Table 7 and one or more alleles selected from alleles numbered 58 to 68 of Table 7.

Provision 58– The vertebrate or cell according to any preceding provision comprising allele number 58 from Table 7 and one or more alleles selected from alleles numbered 59 to 68 of Table 7.

20 Provision 59 The vertebrate or cell according to any preceding provision comprising allele number 59 from Table 7 and one or more alleles selected from alleles numbered 60 to 68 of Table 7.

Provision 60– The vertebrate or cell according to any preceding provision comprising allele number 60 from Table 7 and one or more alleles selected from alleles numbered 61 to 68 of Table 7.

25 Provision 61 – The vertebrate or cell according to any preceding provision comprising allele number 61 from Table 7 and one or more alleles selected from alleles numbered 62 to 68 of Table 7.

30 Provision 62– The vertebrate or cell according to any preceding provision comprising allele number 62 from Table 7 and one or more alleles selected from alleles numbered 63 to 68 of Table 7.

Provision 63— The vertebrate or cell according to any preceding provision comprising allele number 63 from Table 7 and one or more alleles selected from alleles numbered 64 to 68 of Table 7.

5 Provision 64— The vertebrate or cell according to any preceding provision comprising allele number 64 from Table 7 and one or more alleles selected from alleles numbered 65 to 68 of Table 7.

Provision 65— The vertebrate or cell according to any preceding provision comprising allele number 65 from Table 7 and one or more alleles selected from alleles numbered 66 to 68 of Table 7.

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Provision 66— The vertebrate or cell according to any preceding provision comprising allele number 66 from Table 7 and one or more alleles selected from alleles numbered 67 or 68 of Table 7.

15 Provision 67— The vertebrate or cell according to any preceding provision comprising allele number 67 from Table 7 and allele number 68 from Table 7.

In an example, the vertebrate or cell according to any preceding provision comprises one or more or all JH alleles from Table 7, eg, JH2*02 and/or at least JH6*02 (which is useful
20 for producing long HCDR3 V domains for human therapeutic use as shown in the examples).

Thus, each allele combined with any other allele in Table 7 is explicitly disclosed herein. The same structure of combinations is disclosed in relation to the alleles of Table 12 and
25 Table 18. Therefore, each allele in Table 7 combined with any other allele in Table 12 or Table 18 is disclosed, and each allele in Table 12 is disclosed in combination with every other allele in Table 12, and each allele in Table 18 is disclosed in combination with every other allele in Table 18.

30 In an example, the vertebrate or cell according to any preceding provision comprises one or more or all Jk alleles from Table 12, eg, at least Jk2*01 and/or Jk4*01 (which is useful for producing Vk domains for human therapeutic use as shown in the examples).

In one embodiment, the cell or vertebrate of the invention has a genome comprising the
35 gene segments VH3-23*04, JH2*01, VK4-1*01 and/or JK2*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-7*01, JH6*02, VK2-28*01 and/or JK4*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH7-4-1*01, JH6*02, VK2-28*01 and/or JK4*01. Optionally the
5 genome further comprises D3-16*02.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH4-4-1*02, JH6*02, VK1D-13*01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising
10 the gene segments VH1-3*01, JH6*02, VK1-12*01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-13*01, JH6*02, VK1D-12*02 and/or JK4*01. Optionally the genome further comprises D3-9*01.

15 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH4-4*02, JH6*02, VK1D-13*01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-13*01, JH6*02, VK3-20*01 and/or JK4*01. Optionally the
20 genome further comprises D3-10*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-23*04, JH6*02, VK1-17*01 and/or JK4*01. Optionally the genome further comprises D3-22*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising
25 the gene segments VH3-7*01, JH6*02, VK1D-39*01 and/or JK4*01. Optionally the genome further comprises D3-9*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-13*01, JH6*02, VK1D-39*01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-13*01, JH6*02, VK3-11*01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

5 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH4-4*02, JH6*02, VK1D-16*01 and/or JK4*01. Optionally the genome further comprises D3-9*01.

In a further embodiment, the cell or vertebrate of the invention has a genome comprising the gene segments VH3-20*d01, JH6*02, VK1-9*d01 and/or JK4*01. Optionally the genome further comprises D3-10*01.

10 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the human gene segment VH3-23*04. Additionally or alternatively, heavy chain variable domains of the antibody of the invention are encoded by (i) human VH3-23*04, D and JH segments.

15 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the human gene segment VH3-9*01. Additionally or alternatively, heavy chain variable domains of the antibody of the invention are encoded by (i) human VH3-9*01, D and JH segments.

20 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the human gene segment Vk1-12*02 or Vk1D-12*02. Additionally or alternatively, light chain variable domains of the antibody of the invention are encoded by (i) human Vk1-12*02 or Vk1D-12*02 and Jk segments.

25 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the human gene segment Vk2-28*01. Additionally or alternatively, light chain variable domains of the antibody of the invention are encoded by (i) human Vk2-28*01 and Jk segments.

30 In a further embodiment, the cell or vertebrate of the invention has a genome comprising the human gene segment Vk4-1*01. Additionally or alternatively, light chain variable domains of the antibody of the invention are encoded by (i) human Vk4-1*01 and Jk segments. In a further embodiment, the cell or vertebrate of the invention has a genome comprising the combination of gene segments described above with JH6*01 in place of JH6*02.

In all embodiments described herein, the heavy chain V and J region can optionally be recombined with each other and with a D region defined herein to form a heavy chain variable domain. In addition, the light chain V and J regions can optionally be recombined to form a light chain variable domain.

- 5 The invention extends to an antibody or antigen binding fragment comprising human variable domains produced or derived from recombination of any of the above combinations of gene segments.

Antibodies or fragments according to the invention are shown in the examples to be useful for producing productive gene segment recombination *in vivo*, which display
10 junctional mutation and somatic mutation, and produce domains that can specifically bind antigen with good binding kinetics.

The invention includes antibodies or antigen binding fragments thereof that are obtained or obtainable by recombination, *in vivo* in a mouse, mammal or vertebrate of the invention following immunisation, of one or more D gene segments, one or more VH
15 gene segments and one or more of the human JH gene segments J_H2*01 and J_H6*02.

In one embodiment, the cell or vertebrate of the invention can express heavy chains comprising human variable regions derived from recombination of one or more D gene segments, one or more JH gene segments and one or more of the following VH gene segments V_H3-20*d01, V_H1-24*d01 and V_H2-26*d01.

- 20 Therefore, the invention includes antibodies or antigen binding fragments thereof that are obtained or obtainable by recombination, *in vivo* in a mouse, mammal or vertebrate of the invention following immunisation, of one or more D gene segments, one or more JH gene segments and one or more of the human VH gene segments V_H3-20*d01, V_H1-24*d01 and V_H2-26*d01.

- 25 In a further embodiment, the cell or vertebrate of the invention can additionally or alternatively express light chains comprising human variable regions derived from recombination of one or more Jk gene segments and one or more of the human Vk gene segments V_k5-2*d01, V_k1-9*d01, V_k1D-8*d01, V_k3D-11*d01, V_k1D-13*d01, V_k3D-15*d01, V_k2D-26*d01 and V_k2D-28*d01 or recombination of one or more Jλ gene
30 segments and one or more of the human Vλ gene segments Vλ2-22*d01, Vλ2-23*d02, Vλ3-25*d03 and Vλ4-60*d03.

Therefore, the invention includes antibodies or antigen binding fragments thereof that are obtained or obtainable by recombination, *in vivo* in a mouse, mammal or vertebrate of the invention following immunisation, of one or more Jk gene segments and one or more of the human Vk gene segments Vk5-2*d01, Vk1-9*d01, Vk1D-8*d01, Vk3D-11*d01, Vk2D-26*d01 and Vk2D-28*d01 or of one or more Jλ gene segments and one or more of the human Vλ gene segments Vλ2-22*d01, Vλ2-23*d02, Vλ3-25*d03 and Vλ4-60*d03.

In all aspects of the invention, the cell can be a hybridoma cell, a B cell, optionally an immortalised B cell, or an embryonic stem cell.

10 In one embodiment the vertebrate or cell comprises a constant region that is a kappa or lambda constant region; optionally a mouse or rat constant region. In one embodiment the constant region may be a human constant region.

In one embodiment the vertebrate or cell disclosed herein comprises an endogenous light chain locus which is a kappa or lambda locus; optionally wherein the genome
15 comprises at least the V and J gene segments of Table 8, 9 or 10 at an endogenous light chain locus, eg the kappa locus and/or at least the V and J gene segments of Table 13 or 14 at an endogenous light chain locus, eg either the lambda or kappa locus.

In one embodiment the vertebrate or cell disclosed herein comprises comprise immunoglobulin light chains comprising human variable regions that are derived from
20 recombination of human Vλ and Jλ gene segments selected from the group consisting of Vλ and Jλ gene segments of Table 18, each such variable region being expressed with a constant region encoded by a Cλ gene segment selected from the group consisting of the Cλ gene segments of Table 18.

In one embodiment the light chains comprise human variable regions derived from
25 recombination of human Vλ and Jλ gene segments selected from the group consisting of Vλ and Jλ gene segments of Table 18.

In all embodiments of the invention, the VH and VL domains can optionally form an antigen binding site.

The cell of any aspect of the invention can be a hybridoma cell or a B cell, optionally an
30 immortalised B cell. The cell can also be an ES cell. The ES cell can be part of a population of at least 90, 150 or more than 200 cells. In an example, the population of cells is contained on one or more multi-well plates (eg, 96-well plates) and may, for

example, be a sorted population where single cells are comprised by different, respective wells of a plate. The vertebrate of any aspect can be comprised within a container comprising filtered air, optionally comprising an air filter.

5 In an embodiment, the container inner environment is sterile, eg, as possible using a standard animal container, eg, a Techniplast™ mouse loft (<http://www.tecniplast.it/us/product/mouse-loft.html>). In an example, the container has a plastic body, eg, a translucent or transparent body.

The container comprising the vertebrates may have a volume of no more than four, 3, 2 or 1 metres³. The container can comprise a plurality of vertebrates, eg, a male and a
10 female (eg, a fertile pair).

In one embodiment the vertebrates of the invention are at least 3.5 weeks old, eg 4 weeks, 5 weeks, 6 weeks, 7 weeks old.

The use of the gene segments as claimed, specifically as indicated in tables 1-18, provides for the advantages seen in the Examples.

15 The invention further relates to a method of producing an antibody or an antigen binding fragment thereof, the method comprising immunising a vertebrate of the invention with an antigen and recovering the antibody or fragment or recovering a cell producing the antibody or fragment; optionally modifying the isolated antibody or fragment so that it comprises human constant regions.

20 The invention also includes a method of producing an antibody or an antigen binding fragment thereof, the method comprising isolating an antibody or antigen binding fragment thereof from a cell of the invention; and optionally modifying the isolated antibody or fragment so that it comprises human constant regions.

Recombinant DNA technology can be used to produce a modified nucleotide sequence
25 encoding the modified antibody or fragment.

The method may comprise

- (a) isolating from the vertebrate a B-cell encoding an antibody that binds the antigen,
- (b) identifying or copying a nucleotide sequence of the B-cell that encodes a VH domain of the antibody and/or identifying or copying nucleotide sequence of the B-cell
30 that encodes a VL domain of the antibody; and

(c) using the sequence(s) to produce an isolated antibody comprising the VH and/or VL domain; optionally wherein the isolated antibody comprises human constant regions. The invention includes a method for producing a fully humanised antibody comprising immunizing a vertebrate as disclosed herein and then replacing the non-human
5 vertebrate constant region of an antibody specifically reactive with the antigen with a human constant region, suitably by engineering of the nucleic acid encoding the antibody.

The invention also relates to a humanised antibody produced according to any methods
10 disclosed herein and use of a humanised antibody so produced in medicine. In a further embodiment, the invention includes isolating an IgG1, IgG2b and/or IgM antibody that specifically binds the target antigen.

An isolated antibody of the invention may be produced by expression from a host cell
15 selected from a CHO, HEK293, Cos or yeast (eg, Picchia) cell. In a preferred embodiment, the antibody is an antibody produced by expression from a CHO cell.

In a further embodiment the isolated antibody or fragment may be formulated with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human
20 medical use. Optionally the formulated antibody may be packaged in a sterile container, for example, a vial, tube, IV bag or syringe, further optionally producing a kit comprising combining the package with a label or instructions indicating use of the antibody composition for human medical use; optionally wherein the label or instructions comprises a medicament batch number and/or a marketing authorisation number, further
25 optionally an EMA or FDA marketing authorisation number. In an example, the isolated antibody (eg, produced by a CHO cell) (i) is formulated with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human medical use, (ii) the formulated antibody is packaged in a sterile container combined with a label or instructions indicating use of the antibody composition for human medical use; wherein
30 the label or instructions comprises a medicament batch number and/or a marketing authorisation number (eg, an EMA or FDA marketing authorisation number). In an embodiment of such an example, the antibody specifically binds human PCSK9 and the use is for treating or preventing hyperlipidaemia or for reducing cholesterol in a human. In an embodiment of such an example, the antibody specifically binds human IL6Ra and
35 the use is for treating or preventing an inflammatory condition or rheumatoid arthritis in a human. In an embodiment of such an example, the antibody specifically binds human IL4Ra and the use is for treating or preventing an atopic disease, atopic dermatitis or

asthma in a human.

The invention relates to the antibody or fragment produced by the method of the invention for human medical use and to use of the isolated antibody or fragment
5 produced by the method of the invention in the manufacture of a medicament for human medical use.

The medicament may be a composition or kit disclosed herein.

10 The invention includes antibodies and antigen binding fragments thereof comprising human variable domains produced by or derived from recombination of any combination of gene segments disclosed herein, optionally wherein the antibody and fragments are obtained or obtainable by recombination, *in vivo* in a mouse, mammal or other vertebrate of the invention following immunisation.

15 In one embodiment the immunoglobulin heavy chains expressed by the cell or vertebrate are essentially exclusively said heavy chains comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG antibodies, optionally IgG1, IgG2a or IgG2b, or IgM antibodies.

20 In one embodiment, the cell or vertebrate of the invention expresses an IgG antibody, optionally a IgG1, IgG2a or IgG2b antibody, or a IgM antibody comprising heavy chains as defined herein, wherein the antibody specifically binds a target antigen.

The invention further relates to:

25 The antibody, optionally, produced by a method of the invention comprising

(a) a human heavy chain variable domain derived from recombination of human VH, D and JH gene segments selected from the group consisting of VH, D and JH gene segments of any one of Tables 1-7; and

30 (b) a human light chain variable domain derived from recombination of human V and J gene segments both selected from the V and J gene segments of any one of Tables 8-18.

35 An isolated antibody or antigen binding fragment thereof, optionally obtained or obtainable by the method of the invention, wherein a variable region of the antibody or fragment comprises one or more mouse or rat activation-induced deaminase (AID)

pattern somatic mutations and/or mouse or rat terminal deoxynucleotidyl transferase (TdT) pattern junctional mutations.

5 The variable heavy or light domain or region in accordance with invention can comprises up to 10, including 1, 2, 3, 4, 5, 6, 7, 8, or 9 junctional mutations.

In a further embodiment, the variable heavy or light domain or region in accordance with invention can additionally or alternatively comprise up to 9, including 1, 2, 3, 4, 5, 6, 7, 8, or 8, including 1, 2, 3, 4, 5, 6 or 7, somatic mutations.

10

In a further embodiment, the invention includes an isolated antibody or antigen binding fragment thereof, optionally obtained or obtainable by the method of the invention, that binds a gamma receptor, and further optionally a human constant light chain. In one embodiment, the Fc comprises human gamma constant domains, e.g. human IgG1, IgG2, IgG3 or IgG4 constant domains.

15

An isolated antibody or antigen binding fragment thereof, optionally obtained or obtainable by the method of the invention, wherein the antibody comprises CHO, HEK293, Cos or yeast (eg, *Picchia*) cell glycosylation.

An antibody or fragment of the invention can specifically bind a human enzyme.

20 An antibody or fragment of the invention can specifically bind the human targets: proprotein convertase PC9, proprotein convertase subtilisin kexin-9 (PCSK9), CD126, IL-4, IL-4 receptor, IL-6, IL-6 receptor, IL-13, IL-18 receptor, Erbb3, cell ASIC1, ANG2, GDF-8, angiopoietin ligand-2, delta-like protein ligand 4, immunoglobulin G1, PDGF ligand, PDGF receptor or NGF receptor, toxin A or toxin B of *Clostridium difficile*, relaxin, CD48, Cd20, glucagon receptor, protease activated receptor 2, TNF-Like ligand 1A (TL1A), angiopoietin related-2 (AR-2), angiopoietin-like protein 4, RANKL, angiopoietin-like protein 3 (ANGPTL3), delta-like ligand 4 (DLL4), big endothelin-1 (ET-1), activin A, receptor tyrosine kinases, for example human AR-1 and tyrosine kinase with Ig and EGF
25 homology domains (TIE) or TIE-2 receptor. In an example, the target is PCSK9. In an example, the target is IL-6 receptor (eg, IL6Ra). In an example, the target is IL-4
30 receptor (eg, IL4Ra).

Preferred aspects of the invention include:

The use of the antibody or fragment thereof in the manufacture of a medicament for use to attenuate or inhibit an IL-4Ra-mediated disease or disorder in a human. IL-4Ra-

mediated or related disorders which are treated by the ligand, antibody or fragment of the invention include, for example, arthritis (including septic arthritis), herpetiformis, chronic idiopathic urticaria, scleroderma, hypertrophic scarring, Whipple's Disease, benign prostate hyperplasia, lung disorders, such as mild, moderate or severe asthma, inflammatory disorders such as inflammatory bowel disease, allergic reactions, Kawasaki disease, sickle cell disease, Churg-Strauss syndrome, Grave's disease, pre-eclampsia, Sjogren's syndrome, autoimmune lymphoproliferative syndrome, autoimmune hemolytic anemia, Barrett's esophagus, autoimmune uveitis, tuberculosis, and nephrosis.

Further IL-4Ra-mediated or related disorders which are treated by the ligand, antibody or fragment of the invention include, for example, asthma, COPD (eg, chronic bronchitis, small airway disease or emphysema), inflammatory bowel disease, a fibrotic condition (eg, systemic sclerosis, pulmonary fibrosis, parasite-induced liver fibrosis, or cystic fibrosis), allergy (for example atopic dermatitis, dust mite allergy, pet allergy or food allergy), transplation therapy to prevent transplant rejection, suppression of a delayed-type hypersensitivity or a contact hypersensitivity reaction, as an adjuvant to allergy immunotherapy or as a vaccine adjuvant.

Further encompassed by the invention is the use of the antibody or fragment thereof in the manufacture of a medicament for prevention or treatment of a IL-4Ra-mediated or related disorder, wherein said disease or condition is an inflammatory disease or condition; an atopic disease or condition; a respiratory disease or condition; a disease or condition associated with elevated IgE; or a disease or condition associated with elevated IL-4 and/or IL-13 activity.

Further encompassed by the invention is the use of the antibody or fragment thereof in the manufacture of a medicament for prevention or treatment of a IL-4Ra-mediated or related disease or condition, wherein said disease or condition is selected from the group consisting of an airway inflammatory disease or condition, chronic obstructive pulmonary disease, asthma, pneumonia, hypersensitivity pneumonitis, pulmonary infiltrate with eosinophilia, environmental lung disease, pneumonia, bronchiectasis, cystic fibrosis, interstitial lung disease, primary pulmonary hypertension, pulmonary thromboembolism, disorders of the pleura, disorders of the mediastinum, disorders of the diaphragm, hypoventilation, hyperventilation, sleep apnea, acute respiratory distress syndrome, mesothelioma, sarcoma, graft rejection, graft versus host disease, lung cancer, allergic rhinitis, allergy, asbestosis, aspergilloma, aspergillosis, bronchiectasis,

chronic bronchitis, emphysema, eosinophilic pneumonia, idiopathic pulmonary fibrosis, invasive pneumococcal disease, influenza, nontuberculous mycobacteria, pleural effusion, pneumoconiosis, pneumocytosis, pneumonia, pulmonary actinomycosis, pulmonary alveolar proteinosis, pulmonary anthrax, pulmonary edema, pulmonary embolus, pulmonary inflammation, pulmonary histiocytosis X, pulmonary hypertension, pulmonary nocardiosis, pulmonary tuberculosis, pulmonary veno-occlusive disease, rheumatoid lung disease, sarcoidosis, and Wegener's granulomatosis.

Further encompassed by the invention is an anti-IL-4Ra antibody or fragment thereof, as disclosed herein, for prevention or treatment of any disease or disorder disclosed herein.

Further encompassed by the invention is the use of an anti-IL-4Ra antibody or fragment thereof, in a method of medical treatment of a disease or disorder disclosed herein.

Further encompassed by the invention is the use of the ligand, antibody or fragment of the invention in the manufacture of a medicament for use to attenuate or inhibit a PCSK9-mediated disease or disorder in a human. Non-limiting examples of such diseases or conditions can include, for example, a lipid disorder, hyperlipoproteinemia, hyperlipidemia; dyslipidemia; hypercholesterolemia, a heart attack, a stroke, coronary heart disease, atherosclerosis, peripheral vascular disease, claudication, type II diabetes, high blood pressure, and a cardiovascular disease or condition.

Further encompassed by the invention is an anti-PCSK9 antibody or fragment thereof, as disclosed herein, for prevention or treatment of any disease or disorder disclosed herein.

Further encompassed by the invention is the use of an anti-PCSK9 antibody or fragment thereof, in a method of medical treatment of a disease or disorder disclosed herein.

Further encompassed by the invention is the use of the ligand, antibody or fragment of the invention in the manufacture of a medicament for use to attenuate or inhibit an IL-6Ra-mediated disease or disorder in a human.

Said IL-6Ra-mediated disease or condition can be an inflammatory disease or condition. Said IL-6Ra-mediated disease or condition can be selected from the group consisting of an inflammatory bowel disease (IBD), Crohn's disease, rheumatoid arthritis, psoriasis, bronchiolitis, gingivitis, transplant rejection, allogeneic transplant rejection, graft-versus-

host disease (GvHD), asthma, adult respiratory distress syndrome (ARDS), septic shock, ulcerative colitis, Sjorgen's syndrome, airway inflammation, Castleman's disease, periodontitis, atopic dermatitis, systemic lupus erythematosus and coronary heart disease.

- 5 Further encompassed by the invention is an anti-IL-6Ra antibody or fragment thereof, as disclosed herein, for prevention or treatment of any disease or disorder disclosed herein.

Further encompassed by the invention is the use of an anti-IL-6Ra antibody or fragment thereof, in a method of medical treatment of a disease or disorder disclosed herein.

- 10 In a further embodiment, the invention relates to the following aspects:

1. A non-human vertebrate or vertebrate cell (eg, a mouse or rat) whose genome comprises human JH2*01 and/or human JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at an endogenous heavy chain locus and/or human Jk2*01 and/or human Jk4*01 and one or more human Vk gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the cell or vertebrate is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein the heavy chain is produced by recombination of the human JH2*01 and/or JH6*02 segment with a D segment and a VH segment and/or the antibody light chain is produced by recombination of the human Jk2*01 and/or Jk4*01 segment with a Vk segment

25

wherein said one or more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01

30

or

wherein said one or more human Vk gene segments comprise or consist of one, more or all human VH gene segments selected from the group consisting of Vk4-

1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

Optionally the human gene segment is the recombined form of the gene segment that includes one or more mutations relative to the germline human gene segment sequence

2. The cell or vertebrate of aspect 1 wherein the genome comprises human JH2*01 and/or human JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at an endogenous heavy chain locus and or human Jk2*01 and/or human Jk4*01 and one or more human Vk gene segments upstream of a constant region at an endogenous light chain locus,

3. The cell or vertebrate of aspect 2 wherein said one or more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01 and wherein said one or more human Vk gene segments comprise or consist of one, more or all human VH gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

4 The cell or vertebrate of aspect 1-3 wherein the genome comprises VH3-23*04, optionally wherein the heavy chain is produced by recombination of a human JH segment with a D segment and said VH segment.

5 The cell or vertebrate of aspect 1-4 wherein the genome comprises Vk4-1*01, optionally wherein the heavy chain is produced by recombination of a human JH segment with a D segment and said VH segment

6 The cell or vertebrate of aspect 1-5 wherein the genome comprises Vk2-28*01, optionally wherein the heavy chain is produced by recombination of a human JH segment with a D segment and said VH segment

7 The cell or vertebrate of aspect 1-6 wherein the genome comprises Vk1-12*01., optionally wherein the heavy chain is produced by recombination of a human JH segment with a D segment and said VH segment

- 8 The cell or vertebrate of aspect 1-7 wherein the genome comprises JH2*01 and Jk2*01.
- 9 The cell or vertebrate of aspect 1-8 wherein the genome comprises JH6*02 and Jk4*01.
- 5 10 The cell or vertebrate of aspect 1-9 wherein said heavy chain locus comprises VH3-23*04 recombined with JH2*01; or VH3-7*01 recombined with JH6*02.
- 11 The cell or vertebrate of aspect 1-10 wherein said light chain locus comprises Vk4-1*01 recombined with Jk2*01; or Vk2-28*01 recombined with Jk4*01.
- 12 The cell or vertebrate of any preceding aspect, wherein the genome comprises
10 VH3-23*04, JH2*01 (optionally recombined with the VH3-23*04), Vk4-1*01 and Jk2*01 (optionally recombined with the Vk4-1*01).
- 13 The cell or vertebrate of any preceding aspect, wherein the genome comprises VH3-7*01, JH6*02 (optionally recombined with the VH3-7*01), Vk2-28*01 and Jk4*01 (optionally recombined with the Vk2-28*01).
- 15 14 The cell or vertebrate of any preceding aspect, the heavy chain locus further comprising one or more additional heavy chain gene segments from Table 7.
- 15 The cell or vertebrate of any preceding aspect, the heavy chain locus comprising all of the gene segments of Table 1, all of the gene segments of Table 2, all of the gene segments of Table 3, all of the gene segments of Table 4, all of the gene segments of
20 Table 5, all of the gene segments of Table 6 or all of the gene segments of Table 7.
- 16 The cell or vertebrate of any preceding aspect, the light chain locus further comprising one or more additional light chain segments from Table 12.
- 17 The cell or vertebrate of any preceding aspect, the light chain locus comprising all of the gene segments of Table 8, all of the gene segments of Table 9, all of the gene segments of Table 10, all of the gene segments of Table 11 or all of the gene segments
25 of Table 12.
- 18 The cell or vertebrate of any preceding aspect, wherein the cell is a hybridoma or a B-cell (eg, an immortalised B cell).
- 19 The vertebrate or cell of any preceding aspect, wherein the immunoglobulin
30 heavy chains expressed by the mouse are essentially exclusively said heavy chains

comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies.

20 A method of producing an antibody or an antigen binding fragment thereof, the
5 method comprising immunising a vertebrate of aspects 1 to 19 with an antigen and recovering the antibody or fragment or recovering a cell producing the antibody or fragment; optionally modifying the produced antibody or fragment so that it comprises human constant regions,

wherein the variable domains of said antibody are encoded by

10 human gene segments JH2*01 or JH6*02 and one or more human VH gene segments and one or more human D gene segments;

wherein the human VH gene segment is selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01.

15 and

(b) human gene segments Jk2*01 or Jk4*01 and one or more human Vk gene segments,

wherein the human Vk gene segment is selected from the group consisting of Vk4-1*01,
20 Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.

21 A method according to aspect 20 wherein the antigen is a multi-subunit human protein, a bacterial cytotoxin or a protein expressed as a transmembrane protein on human cells.

25 22 A method of producing an antibody or an antigen binding fragment thereof, the method comprising isolating an antibody or antigen binding fragment thereof from a cell according to any one of aspects 1 to 20; and optionally modifying the isolated antibody or fragment so that it comprises human constant regions.

23 The method of aspect 20, further comprising

30 (a) isolating from the vertebrate a B-cell encoding an antibody that binds the antigen,

- (b) identifying or copying a nucleotide sequence of the B-cell that encodes a VH domain of the antibody and/or identifying or copying nucleotide sequence of the B-cell that encodes a VL domain of the antibody; and
- (c) using the sequence(s) to produce an isolated antibody or fragment
- 5 comprising the VH and/or VL domain; optionally wherein the isolated antibody or fragment comprises human constant regions.
- 24 The method of any one of aspects 20-23, wherein the antibody or fragment is produced by expression from a host cell selected from a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell.
- 10 25 The method of aspect 24, wherein the antibody or fragment is produced by expression from a CHO cell.
- 26 The method of any one of aspects 20-25, further comprising formulating the antibody or fragment with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human medical use, optionally further comprising
- 15 packaging the composition in a sterile container, for example, a vial, tube, IV bag or syringe, further optionally producing a kit comprising combining the package with a label or instructions indicating use of the antibody composition for human medical use; optionally wherein the label or instructions comprises a medicament batch number and/or a marketing authorisation number, further optionally an EMA or FDA marketing
- 20 authorisation number.
- 27 The method of any one of aspects 20-26, wherein the vertebrate is according to any one of aspects 1 to 19 and the antibody or fragment produced by the method comprises
- 25 (a) a human heavy chain variable domain is a recombinant of human JH2*01 or human JH6*02, one or more human VH gene segments and one or more human D gene segments; and
- (b) a human light chain variable domain is a recombinant of human JK2*01 or human
- 30 JK4*01 and one or more human Vk gene segments.
- 28 The method of aspect 27, wherein the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-23*04 and JH2*01 and a human light chain variable domain recombinant of Vk4-1*01 and Jk2*01.

- 29 The method of aspect 27, wherein the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-7*01 and JH6*02 and a human light chain variable domain recombinant of Vk2-28*01 and Jk4*01.
- 30 An isolated antibody or fragment or kit produced by the method of any one of aspects 20-29
- 31 An isolated antibody or antigen binding fragment thereof or kit produced by the method of aspects 20-29 wherein the antibody is humanised.
- 32 A composition comprising an antibody or fragment or kit produced by the method of aspects 20-29 wherein the antibody or fragment is the only therapeutic agent.
- 33 A composition comprising an antibody or fragment or kit produced by the method of aspects 20-29 further comprising an additional therapeutic agent, for example, an anti-hypercholesterolemia drug.
- 34 An isolated antibody or fragment or kit produced by the method of any one of aspects 20-29 for human medical use.
- 35 Use of the isolated antibody or fragment produced by the method of any one of aspects 20-29 in the manufacture of a medicament for human medical use.
- 36 The use of aspect 35, wherein the medicament is comprised by a composition or kit as recited in aspect 26.
- 37 An isolated antibody or fragment or kit according to aspect 30-34, or use according to aspect 35-36, which can specifically bind a human target selected from: proprotein convertase PC9, proprotein convertase subtilisin kexin-9 (PCSK9), CD126, IL-4, IL-4 receptor, IL-6, IL-6 receptor, IL-13, IL-18 receptor, Erbb3, cell ASIC1, ANG2, GDF-8, angiopoietin ligand-2, delta-like protein ligand 4, immunoglobulin G1, PDGF ligand, PDGF receptor or NGF receptor, toxin A or toxin B of Clostridium difficile, relaxin, CD48, Cd20, glucagon receptor, protease activated receptor 2, TNF-Like ligand 1A (TL1A), angiopoietin related-2 (AR-2), angiopoietin-like protein 4, RANKL, angiopoietin-like protein 3 (ANGPTL3), delta-like ligand 4 (DLL4), big endothelin-1 (ET-1), activin A, receptor tyrosine kinases, for example human AR-1 and tyrosine kinase with Ig and EGF homology domains (TIE) and TIE-2 receptor.
- 38 An isolated antibody or fragment or kit according to aspect 30-34, or use according to aspect 35-36, for use in treatment of a human in need thereof, wherein the

treatment comprises delivery of an effective amount of an antibody or fragment which specifically binds to a virus or an antigen selected from a human cytokine, growth factor, hormone, enzyme and a serum protein.

39 A host cell, for example a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell,
5 expressing an antibody or fragment produced by the method of any one of aspects 20-29.

In the aspects described above, JH6*02 can be replaced with JH6*01.

In a further aspect, the invention includes the following clauses:

10 CLAUSES

1. A non-human vertebrate cell (eg, a mouse cell or rat cell) whose genome comprises human JH2*01 and/or human JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region
15 at an endogenous heavy chain locus and human Jk2*01 and/or human Jk4*01 and one or more human Vk gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop
20 into a vertebrate that expresses an antibody heavy chain and an antibody light chain, wherein the heavy chain is produced by recombination of the human JH2*01 and/or JH6*02 segment with a D segment and a VH segment and the light chain is produced by recombination of the human Jk2*01 and/or Jk4*01 segment with a Vk segment.

25 2. A non-human vertebrate (eg, a mouse or rat) whose genome comprises human JH2*01 and/or human JH6*02, one or more human VH gene segments and one or more human D gene segments upstream of a constant region at an endogenous heavy chain locus and human Jk2*01 and/or human Jk4*01 and one or more human
30 Vk gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate is capable of producing an antibody heavy chain and an antibody light chain, wherein the heavy chain is produced by recombination of the human JH2*01 and/or JH6*02 segment with a D segment and a VH segment

and the antibody light chain is produced by recombination of the human Jk2*01 and/or Jk4*01 segment with a Vk segment.

3. The cell of clause 1 or vertebrate of clause 2, wherein the genome comprises JH2*01 and Jk2*01.
- 5 4. The cell of clause 1 or 3 or the vertebrate of clause 2 or 3, wherein the genome comprises JH6*02 and Jk4*01.
5. The cell or vertebrate of any preceding clause, wherein said one or more human VH gene segments of the heavy chain locus comprise or consist of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01.
- 10 6. The cell or vertebrate of clause 5, wherein said heavy chain locus comprises VH3-23*04 recombined with JH2*01; or VH3-7*01 recombined with JH6*02.
7. The cell or vertebrate of any preceding clause, wherein said one or more human Vk gene segments comprise or consist of one, more or all human VH gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02, Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.
- 15 8. The cell or vertebrate of clause 5, wherein said light chain locus comprises Vk4-1*01 recombined with Jk2*01; or Vk2-28*01 recombined with Jk4*01.
- 20 9. The cell or vertebrate of any preceding clause, wherein the genome comprises VH3-23*04, JH2*01 (optionally recombined with the VH3-23*04), Vk4-1*01 and Jk2*01 (optionally recombined with the Vk4-1*01).
10. The cell or vertebrate of any preceding clause, wherein the genome comprises VH3-7*01, JH6*02 (optionally recombined with the VH3-7*01), Vk2-28*01 and Jk4*01 (optionally recombined with the Vk2-28*01).
- 25 11. The cell or vertebrate of any preceding clause, the heavy chain locus further comprising one or more additional heavy chain gene segments from Table 7.
12. The cell or vertebrate of any preceding clause, the heavy chain locus comprising all of the gene segments of Table 1, all of the gene segments of Table 2, all of the gene segments of Table 3, all of the gene segments of Table 4, all of the gene segments of Table 5, all of the gene segments of Table 6 or all of the gene segments of Table 7.
- 30

13. The cell or vertebrate of any preceding clause, the light chain locus further comprising one or more additional light chain segments from Table 12.
14. The cell or vertebrate of any preceding clause, the light chain locus comprising all of the gene segments of Table 8, all of the gene segments of Table 9, all of the gene
5 segments of Table 10, all of the gene segments of Table 11 or all of the gene segments of Table 12.
15. The cell or vertebrate of any preceding clause, wherein the cell is a hybridoma or a B-cell (eg, an immortalised B cell).
16. The vertebrate or cell of any preceding clause, wherein the immunoglobulin heavy
10 chains expressed by the mouse are essentially exclusively said heavy chains comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies.
17. A method of producing an antibody or an antigen binding fragment thereof, the
15 method comprising immunising a vertebrate of clauses 2 to 16 with an antigen and recovering the antibody or fragment or recovering a cell producing the antibody or fragment; optionally modifying the produced antibody or fragment so that it comprises human constant regions.
18. A method of producing an antibody or an antigen binding fragment thereof, the
20 method comprising isolating an antibody or antigen binding fragment thereof from a cell according to any one of clauses 1 and 3 to 16; and optionally modifying the isolated antibody or fragment so that it comprises human constant regions.
19. The method of clause 17 or clause 18, further comprising
- (a) isolating from the vertebrate a B-cell encoding an antibody that binds the
25 antigen,
- (b) identifying or copying a nucleotide sequence of the B-cell that encodes a VH domain of the antibody and/or identifying or copying nucleotide sequence of the B-cell that encodes a VL domain of the antibody; and
- (c) using the sequence(s) to produce an isolated antibody or fragment
30 comprising the VH and/or VL domain; optionally wherein the isolated antibody or fragment comprises human constant regions.

20. The method of any one of clauses 17-19, wherein the antibody or fragment is produced by expression from a host cell selected from a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell.
21. The method of any one of clauses 17-20, further comprising formulating the antibody or fragment with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human medical use, optionally further comprising packaging the composition in a sterile container, for example, a vial, tube, IV bag or syringe, further optionally producing a kit comprising combining the package with a label or instructions indicating use of the antibody composition for human medical use; optionally wherein the label or instructions comprises a medicament batch number and/or a marketing authorisation number, further optionally an EMA or FDA marketing authorisation number.
22. The method of any one of clauses 17-21, wherein the vertebrate is according to any one of clauses 2 to 16 and the antibody or fragment produced by the method comprises
- (a) a human heavy chain variable domain is a recombinant of human JH2*01 or human JH6*02, one or more human VH gene segments and one or more human D gene segments; and
- (b) a human light chain variable domain is a recombinant of human JK2*01 or human JK4*01 and one or more human Vk gene segments.
23. The method of clause 22, wherein the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-23*04 and JH2*01 and a human light chain variable domain recombinant of Vk4-1*01 and Jk2*01.
24. The method of clause 22, wherein the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-7*01 and JH6*02 and a human light chain variable domain recombinant of Vk2-28*01 and Jk4*01.
25. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of clauses 17-24, wherein a heavy and/or light chain variable domain of the antibody or fragment comprises one or more mouse or rat activation-

induced deaminase (AID) pattern somatic mutations and/or mouse or rat terminal deoxynucleotidyl transferase (TdT) pattern junctional mutations.

26. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of clauses 17-24, or an antibody according to clause 25 comprising a human heavy chain Fc fragment, optionally that binds a gamma receptor, and further optionally a human constant light chain.
27. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of clauses 17-24, or an antibody according to clause 25 or clause 26 comprising an antigen binding site capable of specifically binding to a virus or an antigen selected from a human cytokine, growth factor, hormone, enzyme and a serum protein.
28. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of clauses 17-24, or an antibody according to any one of clauses 25-27, wherein said antibody or fragment is glycosylated, optionally comprising CHO, HEK293, Cos or yeast (eg, *Picchia*) cell glycosylation.
29. An isolated antibody or antigen binding fragment thereof, wherein the variable domains of said antibody are encoded by
- (a) human gene segments JH2*01 or JH6*02 and one or more human VH gene segments and one or more human D gene segments; and
- (b) human gene segments Jk2*01 or Jk4*01 and one or more human Vk gene segments.
30. The antibody of clause 29, wherein the variable domains are encoded by the human gene segments (i) JH2*01 and VH3-23*04 for the VH domain and (ii) Vk4-1*01 and Jk2*01 for the VL domain.
31. The antibody of clause 29, wherein the variable domains are encoded by the human gene segments (i) JH6*02 and VH3-7*01 for the VH domain and (ii) Vk2-28*01 and Jk4*01 for the VL domain.
32. An isolated antibody or antigen binding fragment thereof of any one of clauses 25-31, wherein the antibody is humanised.
33. A composition comprising an antibody or fragment of any one of clauses 25-32, wherein the antibody or fragment is the only therapeutic agent.

34. A composition comprising an antibody or fragment of any one of clauses 25-32, further comprising an additional therapeutic agent, for example, an anti-hypercholesterolemia drug.
35. The isolated antibody or fragment produced by the method of any one of clauses 17-24 or the isolated antibody or fragment of any one of clauses 25 to 34 for human medical use.
36. Use of the isolated antibody or fragment produced by the method of any one of clauses 17-24 or the isolated antibody or fragment of any one of clauses 25-34 in the manufacture of a medicament for human medical use.
37. The use of clause 36, wherein the medicament is comprised by a composition or kit as recited in clause 21.
38. A method of medical treatment comprising delivery an effective amount of isolated antibody or fragment thereof according to clauses 25-34 to a human in need thereof.
39. A host cell, for example a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell, expressing an antibody or fragment as defined in any one of clauses 25-34.

In the clauses described above, JH6*02 can be replaced with JH6*01.

In a further aspect, the invention includes the following provisions:

1. A non-human vertebrate (eg, a mouse or rat) cell whose genome comprises human VH, D and JH gene segments upstream of a constant region at an endogenous heavy chain locus and human VL and JL gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the cell is capable of expressing immunoglobulin heavy and light chains comprising human VH and VL domains respectively, wherein the heavy chain locus comprises a human 01 allele VH gene segment capable of recombining with a human D and JH gene segment to produce a VH domain, wherein the light chain locus comprises a human 01 allele VL gene segment capable of recombining with a human JL gene segment to produce a VL domain, or wherein the cell can develop into a vertebrate that expresses said VH and VL domains.

2. A non-human vertebrate (eg, a mouse or rat) whose genome comprises human VH, D and JH gene segments upstream of a constant region at an endogenous heavy chain locus and human VL and JL gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the vertebrate is capable of expressing immunoglobulin heavy and light chains comprising human VH and VL domains respectively, wherein the heavy chain locus comprises a human 01 allele VH gene segment capable of recombining with a human D and JH gene segment to produce a VH domain and wherein the light chain locus comprises a human 01 allele VL gene segment capable of recombining with a human JL gene segment to produce a VL domain.
3. The cell of provision 1 or vertebrate of provision 2, wherein one or both 01 alleles is a d01 allele.
4. The cell or vertebrate of any preceding provision, wherein the VH and VL domains form an antigen binding site.
5. The cell or vertebrate of any preceding provision, wherein the heavy chain locus comprises no second human allele of said VH gene segment.
6. The cell or vertebrate of any preceding provision, wherein the light chain locus comprises no second human allele of said VL gene segment.
7. The cell or vertebrate of any preceding provision, wherein the heavy chain locus comprises a human 01 allele D gene segment capable of recombining with a human JH gene segment and said human VH segment to produce said VH domain; optionally wherein the heavy chain locus comprises no second human allele of said D gene segment.
8. The cell or vertebrate of any preceding provision, wherein the heavy chain locus comprises a human 02 allele JH gene segment (eg, JH6*02) capable of recombining with a human D gene segment and said human VH segment to produce said VH domain; optionally wherein the heavy chain locus comprises no second human allele of said JH gene segment.
9. The cell or vertebrate of any preceding provision, wherein the light chain locus comprises a human 01 allele JL gene segment capable of recombining said human VL segment to produce said VL domain; optionally wherein the light chain locus comprises no second human allele of said JL gene segment.

10. The cell or vertebrate of any preceding provision, wherein the genome comprises VH3-23*04, JH2*01 (optionally recombined with the VH3-23*04), Vk4-1*01 and Jk2*01 (optionally recombined with the Vk4-1*01).
11. The cell or vertebrate of any preceding provision, wherein the genome comprises
5 VH3-7*01, JH6*02 (optionally recombined with the VH3-7*01), Vk2-28*01 and Jk4*01 (optionally recombined with the Vk2-28*01).
12. The cell or vertebrate of any preceding provision, wherein said light chain locus comprises or consists of one, more or all human VL gene segments selected from the group consisting of Vk4-1*01, Vk2-28*01, Vk1D-13*d01, Vk1-12*01, Vk1D-12*02,
10 Vk3-20*01, Vk1-17*01, Vk1D-39*01, Vk3-11*01, Vk1D-16*01 and Vk1-9*d01.
13. The cell or vertebrate of any one of provisions 1 to 9, wherein said light chain locus comprises or consists of one, more or all human VL gene segments selected from the group consisting of Jk4*01 and Jk2*01.
14. The cell or vertebrate of any preceding provision, wherein said heavy chain locus
15 comprises or consists of one, more or all human VH gene segments selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01 and VH3-20*d01.
15. The cell or vertebrate of any one of provisions 1 to 9 or 14, wherein the light chain locus comprises Jλ2*01.
- 20 16. The cell or vertebrate of any one of provisions 1 to 6, wherein said VH domain is a recombinant of human VH, D and JH segments, wherein the VH is selected from the group consisting of one, more or all 01 allele gene VH segments of Table 7 and/or the VL domain is a recombinant of (i) human Vk and Jk gene segments, wherein the
25 Vk is selected from the group consisting of one, more or all 01 allele Vk gene segments of Table 12 or (ii) human Vλ and Jλ gene segments, the Vλ being selected from the group consisting of one, more or all 01 allele Vλ gene segments of Table 18; optionally wherein the VH and/or VL domains are expressed as IgG antibodies.
17. The cell or vertebrate of any one of provisions 1 to 6 and 16, wherein said VH
30 domain is a recombinant of the human VH, D and JH segments of Table 1, Table 2, Table 3, Table 4, Table 5, Table 6 or Table 7 and/or the VL domain is a recombinant of (i) the human Vk and Jk gene segments of Table 8, Table 9, Table 10, Table 11 or Table 12; or (ii) the human Vλ and Jλ gene segments of Table 13, Table 14, Table 15, Table 16, Table 17 or Table 18.

18. The vertebrate of any one of provisions 2 to 17, wherein (a) the heavy chain locus comprises the human VH, D and JH segments of a Table selected from Table 1, Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7 and/or (b) the light chain locus comprises (i) the human Vk and Jk gene segments of a Table selected from Table 8, Table 9, Table 10, Table 11 and Table 12; or (ii) the human Vλ and Jλ gene segments of a Table selected from Table 13, Table 14, Table 15, Table 16, Table 17 and Table 18; and wherein the vertebrate expresses one or a plurality of VH domains each being a recombinant of human VH, D and JH segments from a selected Table of (a) and/or expresses one or a plurality of VL domains each being a recombinant of human VL and JL segments from a selected Table of (b); optionally wherein such VH domains and VL domains form antigen binding sites.
19. A non-human vertebrate (eg, a mouse or rat) whose genome comprises human VH, D and JH gene segments upstream of a constant region at an endogenous heavy chain locus and human VL and JL gene segments upstream of a constant region at an endogenous light chain locus, wherein the gene segments are operably linked to the constant region thereof so that the vertebrate is capable of expressing immunoglobulin heavy and light chains comprising human VH and VL domains respectively, wherein (a) the heavy chain locus comprises the human VH, D and JH segments of a Table selected from Table 1, Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7 and/or (b) the light chain locus comprises (i) the human Vk and Jk gene segments of a Table selected from Table 8, Table 9, Table 10, Table 11 and Table 12; or (ii) the human Vλ and Jλ gene segments of a Table selected from Table 13, Table 14, Table 15, Table 16, Table 17 and Table 18; and wherein the vertebrate expresses one or a plurality of VH domains each being a recombinant of human VH, D and JH segments from a selected Table of (a) and/or expresses one or a plurality of VL domains each being a recombinant of human VL and JL segments from a selected Table of (b); optionally wherein such VH domains and VL domains form antigen binding sites.
20. The cell of any preceding provision, wherein said cell is an ES cell, a hybridoma cell or an immortalised B cell.
21. The vertebrate of any preceding provision, wherein said vertebrate is comprised within a container having an air filter.
22. A population of at least 90 cells, wherein said cells are according to any one of provisions 1 to 17, 19 or 20.

23. The cell, vertebrate or population of any preceding provision, wherein said light chain locus constant region is a kappa or lambda constant region; optionally a mouse or rat constant region.
- 5 24. The cell, vertebrate or population of any preceding provision, wherein the heavy chain locus is a mouse or rat constant region (eg, comprising a gamma constant gene segment).
- 10 25. The cell, vertebrate or population of any preceding provision, wherein said endogenous light chain locus is a kappa or lambda locus; optionally wherein the genome comprises at least the V and J gene segments of Table 8 at an endogenous light chain locus and/or at least the V and J gene segments of Table 13 at an endogenous light chain locus.
- 15 26. The cell, vertebrate or population of any one of provisions 1 to 9 or 14 to 23, wherein said light chains comprise immunoglobulin light chains comprising human variable regions that derived from recombination of human V λ and J λ gene segments selected from the group consisting of V λ and J λ gene segments of Table 18, optionally each such variable region being expressed with a constant region encoded by a C λ gene segment selected from the group consisting of the C λ gene segments of Table 18.
- 20 27. The cell, vertebrate or population of any preceding provision, wherein the vertebrate is a mouse C57Bl/6J, 129S5 or 129Sv strain or a cross between C57Bl/6J and a 129S5 or 129Sv strain.
- 25 28. The cell, vertebrate or population of any preceding provision, wherein the immunoglobulin heavy chains expressed by the cell or vertebrate are essentially exclusively said heavy chains comprising human variable regions; and said heavy chains comprising human variable regions are expressed as part of serum IgG1, IgG2b and IgM (and optionally IgG2a) antibodies.
- 30 29. The cell, vertebrate or population of any preceding provision, wherein the vertebrate expresses light chains comprising human lambda variable regions and at least 60%, 70% or 80% of the variable regions of such light chains are derived from recombination of human V λ and J λ gene segments.
30. A non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments

into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments have been provided by insertion into an endogenous light chain locus of the vertebrate or cell, wherein the vertebrate comprises immunoglobulin light chains comprising lambda variable regions (lambda light chains) or the cell can develop into a vertebrate that expresses said immunoglobulin light chains, wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable regions derived from recombination of human V λ and J λ gene segments; wherein at least 80% of the variable regions of the lambda light chains expressed by the vertebrate are human V λ and J λ gene segment recombinants; wherein the vertebrate or cell is according to any one of provisions 1 to 9 or 14 to 29.

31. A non-human vertebrate (eg, a mouse or rat) or cell whose genome comprises an Ig gene segment repertoire produced by targeted insertion of human Ig gene segments into one or more endogenous Ig loci, the genome comprising human V λ and J λ gene segments upstream of a constant region, wherein the human V λ and J λ gene segments are selected from one, more or all of the segments of Table 18 and have been provided by insertion into an endogenous light chain locus of the vertebrate or cell, wherein the vertebrate comprises immunoglobulin light chains comprising lambda variable regions (lambda light chains) or the cell can develop into a vertebrate that expresses said immunoglobulin light chains, wherein the lambda light chains comprise immunoglobulin light chains comprising lambda variable region recombinants of one or a plurality of human V λ and J λ gene segment pairs, wherein each gene segment is selected from the human V λ and J λ gene segments of Table 18.

32. A method of producing an antibody or an antigen binding fragment thereof, the method comprising immunising a vertebrate of any one of provisions 2 to 19, 21 or 23 to 31 with an antigen and recovering the antibody or fragment or recovering a cell producing the antibody or fragment; optionally modifying the produced antibody or fragment so that it comprises human constant regions.

33. A method of producing an antibody or an antigen binding fragment thereof, the method comprising isolating an antibody or antigen binding fragment thereof from a cell according to any one of provisions 1, 3 to 17, 19 and 23 to 31; and optionally modifying the isolated antibody or fragment so that it comprises human constant regions.

34. The method of provision 33, further comprising
- (a) isolating from the vertebrate a B-cell encoding an antibody that binds the antigen,
 - 5 (b) identifying or copying a nucleotide sequence of the B-cell that encodes a VH domain of the antibody and/or identifying or copying nucleotide sequence of the B-cell that encodes a VL domain of the antibody; and
 - (c) using the sequence(s) to produce an isolated antibody or fragment comprising the VH and/or VL domain; optionally wherein the isolated antibody or
 - 10 fragment comprises human constant regions.
35. The method of any one of provisions 32 to 34, wherein the antibody or fragment is produced by expression from a host cell selected from a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell.
- 15
36. The method of provision any one of provisions 32 to 35, further comprising formulating the antibody or fragment with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human medical use, optionally further comprising packaging the composition in a sterile container, for example, a vial, tube,
- 20 IV bag or syringe, further optionally producing a kit comprising combining the package with a label or instructions indicating use of the antibody composition for human medical use; optionally wherein the label or instructions comprises a medicament batch number and/or a marketing authorisation number, further optionally an EMA or FDA marketing authorisation number.
- 25
37. The method of any one of provisions 32 to 35, wherein the vertebrate is according to any preceding provision and the antibody or fragment produced by the method comprises
- 30 (a) a human heavy chain variable domain recombinant of human VH, D and JH gene segments selected from the group consisting of VH, D and JH gene segments of Table 7; and
 - (b) a human light chain variable domain recombinant of human V and J gene
 - 35 segments selected from the V and J gene segments of Table 12 or selected from the V and J gene segments of Table 18.

38. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of provisions 32 to 35, wherein a heavy and/or light chain variable domain of the antibody or fragment comprises one or more mouse or rat activation-induced deaminase (AID) pattern somatic mutations and/or mouse or rat terminal deoxynucleotidyl transferase (TdT) pattern junctional mutations.
39. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of provision 32 to 35, or an antibody according to provision 38 comprising a human heavy chain Fc fragment, optionally that binds a gamma receptor, and further optionally a human constant light chain.
40. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of provisions 32 to 35, or an antibody according to provision 38 or provision 39 comprising an antigen binding site capable of specifically binding to a virus or an antigen selected from a human cytokine, growth factor, hormone, enzyme and a serum protein.
41. An isolated antibody or antigen binding fragment thereof obtained or obtainable by the method of any one of provisions 32 to 35, or an antibody according to any one of provisions 38 to 40, wherein said antibody or fragment is glycosylated, optionally comprising CHO, HEK293, Cos or yeast (eg, *Picchia*) cell glycosylation.
42. An isolated antibody or antigen binding fragment thereof, wherein the variable domains of said antibody are encoded by (i) human VH, D and JH segments selected from the group consisting of any gene segment of Table 7 and/or (i) human Vk and Jk gene segments selected from the group consisting of any Vk and Jk gene segments of Table 12 or (ii) human Vλ and Jλ gene segments selected from the group consisting of any Vλ and Jλ gene segments of Table 18.
43. An isolated antibody or antigen binding fragment thereof of any one of provisions 38 to 42, wherein the antibody or fragment specifically binds to a virus or an antigen selected from a human cytokine, growth factor, hormone, enzyme and a serum protein.
44. An isolated antibody or antigen binding fragment thereof of any one of provisions 38 to 43, wherein the antibody is humanised.

45. A composition comprising an antibody or fragment of any one of provisions 38 to 44, wherein the antibody or fragment is the only therapeutic agent.
- 5 46. A composition comprising an antibody or fragment of any one of provisions 38 to 44, further comprising an additional therapeutic agent, for example, an anti-rheumatic drug, such as a disease modifying anti-rheumatic drug, or an anti-cancer drug or an anti-hypercholesterolaemia drug.
- 10 47. The isolated antibody or fragment produced by the method of any one of provisions 32 to 35 or the isolated antibody or fragment of any one of provisions 38 to 46 for human medical use.
- 15 48. Use of the isolated antibody or fragment produced by the method of any one of provisions 32 to 35 or the isolated antibody or fragment of provision 38 to 46 in the manufacture of a medicament for human medical use.
49. The use of provision 48, wherein the medicament is comprised by a composition or kit as recited in provision 36.
- 20 50. A method of medical treatment comprising delivery an effective amount of isolated antibody or fragment thereof according to provisions 38 to 46 to a human in need thereof.
- 25 51. A host cell, for example a CHO, HEK293, Cos or yeast (eg, *Picchia*) cell, expressing an antibody or fragment as defined in any one of provisions 38 to 43.

In the provisions described above, JH6*02 can be replaced with JH6*01.

- 30 The following definitions apply to any configuration, aspect, clause, provision, example or embodiment of the invention.

“Derived from” is used in the ordinary sense of the term. Exemplary synonyms include “produced as”, “resulting from”, “received from”, “obtained from”, “a product of”, “consequence of”, and “modified from” For example, a human variable region of a heavy

35 chain can be derived from recombination of human VH, D and JH gene segments and this reflects the *in vivo* recombination of these gene segments in, for example, a

transgenic heavy chain locus according to the invention with any accompanying mutation (eg, junctional mutation).

Samples from which B-cells can be obtained include but are not limited to blood, serum, spleen, splenic tissue, bone marrow, lymph, lymph node, thymus, and appendix.

- 5 Antibodies and immunoglobulin chains can be obtained from each of the previous-mentioned samples and also from the following non-limiting list of B-cells, ascites fluid, hybridomas, and cell cultures.

“Plurality” is used in the ordinary sense of the term and means “at least one” or “more than one”.

- 10 The term “germline configuration” refers to a germline genomic configuration. For example, human immunoglobulin gene segments of a transgenic immunoglobulin locus are in a germline configuration when the relative order of the gene segments is the same as the order of corresponding gene segments in a human germline genome. For example, when the transgenic locus is a heavy chain locus of the invention comprising
- 15 hypothetical human immunoglobulin gene segments A, B and C, these would be provided in this order (5' to 3' in the locus) when the corresponding gene segments of a human germline genome comprises the arrangement 5'-A-B-C-3'. In an example, when elements of a human immunoglobulin locus (eg, gene segments, enhancers or other regulatory elements) are provided in a transgenic immunoglobulin locus according to the
- 20 invention, the human Ig locus elements are in germline configuration when when the relative order of the gene segments is the same as the order of corresponding gene segments in a human germline genome and human sequences between the elements are included, these corresponding to such sequences between corresponding elements in the human germline genome. Thus, in a hypothetical example the transgenic locus
- 25 comprises human elements in the arrangement 5'-A-S1-B-S2-C-S3-3', wherein A, B and C are human immunoglobulin gene segments and S1-S3 are human inter-gene segment sequences, wherein the corresponding arrangement 5'-A-S1-B-S2-C-S3-3' is present in a human germline genome. For example, this can be achieved by providing in a transgenic immunoglobulin locus of the invention a DNA insert corresponding to the DNA
- 30 sequence from A to C in a human germline genome (or the insert comprising the DNA sequence from A to C). The arrangements in human germline genomes and immunoglobulin loci are known in the art (eg, see the IMGT at the World Wide Web (see above), Kabat and other antibody resources referenced herein).

The term "antibody" includes monoclonal antibodies (including full length antibodies which have an immunoglobulin Fc region), antibody compositions with polyepitopic specificity, multispecific antibodies (e.g., bispecific antibodies, diabodies, and single-chain molecules, as well as antibody fragments (e.g., dAb, Fab, F(ab')₂, and Fv). The
5 term "antibody" also includes H2 antibodies that comprise a dimer of a heavy chain (5'-VH-(optional Hinge)-CH₂-CH₃-3') and are devoid of a light chain (akin to naturally-occurring H2 antibodies; see, eg, Nature. 1993 Jun 3;363(6428):446-8; Naturally occurring antibodies devoid of light chains; Hamers-Casterman C, Atarhouch T, Muyldermans S, Robinson G, Hamers C, Songa EB, Bendahman N, Hamers R). Thus,
10 in an embodiment of the present invention, RNA produced from the transgenic heavy chain locus encodes for heavy chains that are devoid of a CH1 gene segment and comprise no functional antibody light chain. In an example, RNA produced from the transgenic heavy chain locus encodes for VH single variable domains (dAbs; domain antibodies). These can optionally comprise a constant region.

15 The term "immunoglobulin" (Ig) is used interchangeably with "antibody" herein.

An "isolated" antibody is one that has been identified, separated and/or recovered from a component of its production environment (e.g., naturally or recombinantly). Preferably, the isolated polypeptide is free of association with all other components from its production environment, eg, so that the antibody has been isolated to an FDA-
20 approvable or approved standard. Contaminant components of its production environment, such as that resulting from recombinant transfected cells, are materials that would typically interfere with research, diagnostic or therapeutic uses for the antibody, and may include enzymes, hormones, and other proteinaceous or non-proteinaceous solutes. In preferred embodiments, the polypeptide will be purified: (1) to
25 greater than 95% by weight of antibody as determined by, for example, the Lowry method, and in some embodiments, to greater than 99% by weight; (2) to a degree sufficient to obtain at least 15 residues of N-terminal or internal amino acid sequence by use of a spinning cup sequenator, or (3) to homogeneity by SDS-PAGE under non-reducing or reducing conditions using Coomassie blue or, preferably, silver stain.
30 Isolated antibody includes the antibody in situ within recombinant cells since at least one component of the antibody's natural environment will not be present. Ordinarily, however, an isolated polypeptide or antibody will be prepared by at least one purification step.

An "antibody fragment" comprises a portion of an intact antibody, preferably the antigen
35 binding and/or the variable region of the intact antibody. Examples of antibody fragments

include dAb, Fab, Fab', F(ab')₂ and Fv fragments; diabodies; linear antibodies; single-chain antibody molecules and multispecific antibodies formed from antibody fragments.

An antibody that "specifically binds to" or is "specific for" a particular polypeptide, antigen, or epitope is one that binds to that particular polypeptide, antigen, or epitope without substantially binding to other polypeptides, antigens or epitopes. For example, binding to the antigen or epitope is specific when the antibody binds with a K_D of 100 μ M or less, 10 μ M or less, 1 μ M or less, 100 nM or less, eg, 10 nM or less, 1 nM or less, 500 pM or less, 100 pM or less, or 10pM or less. The binding affinity (K_D) can be determined using standard procedures as will be known by the skilled person, eg, binding in ELISA and/or affinity determination using surface plasmon resonance (eg, Biacore™ or KinExA™ solution phase affinity measurement which can detect down to fM affinities (Sapidyne Instruments, Idaho)).

"Pharmaceutically acceptable" refers to approved or approvable by a regulatory agency of the USA Federal or a state government or listed in the U.S. Pharmacopeia or other generally recognized pharmacopeia for use in animals, including humans. A "pharmaceutically acceptable carrier, excipient, or adjuvant" refers to a carrier, excipient, or adjuvant that can be administered to a subject, together with an agent, e.g., any antibody or antibody chain described herein, and which does not destroy the pharmacological activity thereof and is nontoxic when administered in doses sufficient to deliver a therapeutic amount of the agent.

Brief Description of the Figures

Fig 1, part 1 illustrates the first and second BACs used for insertion into mouse endogenous light chain loci. The human DNA in each BAC is shown. Part 2 of figure 1 shows the insertion point of human lambda Ig locus DNA into the mouse endogenous kappa chain locus. Part 3 of figure 1 shows the insertion point of human lambda Ig locus DNA into the mouse endogenous lambda chain locus.

Fig 2 shows the results of FACS analysis to determine mouse and human C λ expression (and thus correspondingly mouse and human variable region expression) in B220⁺ splenic B cells from P1 homozygous mice (P1/P1) compared to wild-type mice (WT).

Fig 3A shows the results of FACS analysis to determine mouse C κ and C λ expression in B220⁺ splenic B cells from P2 homozygous mice (P2/P2) compared to wild-type mice (WT). No detectable mouse C κ expression was seen.

Fig 3B shows the results of FACS analysis to determine human C λ expression (and thus correspondingly human variable region expression) in B220⁺ splenic B cells from P2 homozygous mice (P2/P2) compared to wild-type mice (WT).

5 Fig 4 shows human V λ usage in P2 homozygous mice (P2/P2) and typical V λ usage in humans (inset).

Fig 5 shows human J λ usage in P2 homozygous mice (P2/P2) and typical J λ usage in humans (inset).

Fig 6 shows V λ usage is very high in P2 homozygous mice (P2/P2).

10 Fig 7 shows the distribution of mouse V κ and human V λ gene segment usage from the chimaeric kappa locus in P2 homozygous mice (P2/P2).

Fig 8 illustrates RSS arrangement in the lambda and kappa loci.

15 Fig 9A shows the results of FACS analysis to determine mouse and human C λ expression (and thus correspondingly mouse and human variable region expression) in B220⁺ splenic B cells from L2 homozygous mice in which endogenous kappa chain expression has been inactivated (L2/L2; KA/KA) compared to mice having no human lambda DNA inserted and in which endogenous kappa chain expression has been inactivated (KA/KA). Very high human V λ usage was seen in the L2/L2; KA/KA mice, almost to the exclusion of mouse V λ use.

20 Fig 9B: Splenic B-Cell Compartment Analysis. This figure shows the results of FACS analysis on splenic B-cells from transgenic L2/L2; KA/KA mice (L2 homozygotes; homozygous for human lambda gene segment insertion into endogenous lambda loci; endogenous kappa chain expression having been inactivated) compared with splenic B-cells from mice expressing only mouse antibodies (KA/KA mice). The results show that the splenic B-cell compartments in the mice of the invention are normal (ie, equivalent to
25 the compartments of mice expressing only mouse antibody chains).

Fig 10: B-cell development and markers in the bone marrow and splenic compartments.

30 Fig 11A: Splenic B-Cell Compartment Analysis. This figure shows the results of FACS analysis on splenic B-cells from transgenic S1F/HA, KA/+ mice of the invention expressing heavy chain variable regions which are all human (where endogenous heavy chain expression has been inactivated by inversion), compared with splenic B-cells from mice expressing only mouse antibodies. The results show that the splenic B-cell

compartments in the mice of the invention are normal (ie, equivalent to the compartments of mice expressing only mouse antibody chains).

S1F/HA, +/-KA = (i) S1F - first endogenous heavy chain allele has one human heavy chain locus DNA insertion, endogenous mouse VDJ region has been inactivated by inversion and movement upstream on the chromosome; (ii) HA – second endogenous heavy chain allele has been inactivated (by insertion of an endogenous interrupting sequence); (iii) + - first endogenous kappa allele is a wild-type kappa allele; and (iv) KA – the second endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence). This arrangement encodes exclusively for heavy chains from the first endogenous heavy chain allele.

Fig 11B: Splenic B-Cell Compartment Analysis. This figure shows the results of FACS analysis on splenic B-cells from transgenic S1F/HA, K2/KA mice of the invention expressing heavy chain variable regions which are all human (where endogenous heavy chain expression has been inactivated by inversion) and human kappa chain variable regions, compared with splenic B-cells from +/-HA, K2/KA mice. The results show that the splenic B-cell compartments in the mice of the invention are normal.

S1F/HA, K2/KA = (i) K2 – the first endogenous kappa allele has two kappa chain locus DNA insertions between the most 3' endogenous Jk and the mouse Ck, providing an insertion of 14 human Vk and Jk1-Jk5; and (ii) KA – the second endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence). This arrangement encodes exclusively for heavy chains comprising human variable regions and substantially kappa light chains from the first endogenous kappa allele.

+/-HA, K2/KA - this arrangement encodes for mouse heavy chains and human kappa chains.

Fig 12A: Bone marrow B progenitor compartment analysis. This figure shows the results of FACS analysis on bone marrow (BM) B-cells from transgenic S1F/HA, KA/+ mice of the invention expressing heavy chain variable regions which are all human (where endogenous heavy chain expression has been inactivated by inversion), compared with BM B-cells from mice expressing only mouse antibodies. The results show that the BM B-cell compartments in the mice of the invention are normal (ie, equivalent to the compartments of mice expressing only mouse antibody chains).

Fig 12B: Bone marrow B progenitor compartment analysis. This figure shows the results of FACS analysis on bone marrow (BM) B-cells from transgenic S1F/HA, K2/KA mice of

the invention expressing heavy chain variable regions which are all human (where endogenous heavy chain expression has been inactivated by inversion) and human kappa chain variable regions, compared with BM B-cells from +/-HA, K2/KA mice. The results show that the BM B-cell compartments in the mice of the invention are normal.

5 Fig 13: shows Ig quantification for subtype and total Ig in various mice:

S1F/HA, KA/+ = (i) S1F - first endogenous heavy chain allele has one human heavy chain locus DNA insertion, endogenous mouse VDJ region has been inactivated by inversion and movement upstream on the chromosome; (ii) HA – second endogenous heavy chain allele has been inactivated (by insertion of an endogenous interrupting sequence); (iii) KA – the first endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence); and (iv) + - second endogenous kappa allele is a wild-type kappa allele. This arrangement encodes exclusively for heavy chains from the first endogenous heavy chain allele.

15 S1F/HA, K2/KA = (i) K2 – the first endogenous kappa allele has two kappa chain locus DNA insertions between the most 3' endogenous Jk and the mouse Ck, providing an insertion of 14 human Vk and Jk1-Jk5; and (ii) KA – the second endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence). This arrangement encodes exclusively for heavy chains comprising human variable regions and substantially kappa light chains from the first endogenous kappa allele.

20 +/-HA, K2/+ - this arrangement encodes for mouse heavy chains and both mouse and human kappa chains.

+/-HA, +/-KA - this arrangement encodes for mouse heavy and kappa chains.

In this figure, "Sum Ig" is the sum of IgG and IgM isotypes.

25 Fig 14: shows Ig quantification for subtype and total Ig in various mice:

S1F/HA, K2/KA (n=15) and 12 mice expressing only mouse antibody chains (+/-HA, +/-KA (n=6) and wild-type mice (WT; n=6)).

Detailed Description of the Invention

30 It will be understood that particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention can be employed in various embodiments without departing from the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more

than routine study, numerous equivalents to the specific procedures described herein. Such equivalents are considered to be within the scope of this invention and are covered by the claims.

5 The use of the word "a" or "an" when used in conjunction with the term "comprising" in the claims and/or the specification may mean "one," but it is also consistent with the meaning of "one or more," "at least one," and "one or more than one." The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and "and/or." Throughout this
10 application, the term "about" is used to indicate that a value includes the inherent variation of error for the device, the method being employed to determine the value, or the variation that exists among the study subjects.

As used in this specification and claim(s), the words "comprising" (and any form of comprising, such as "comprise" and "comprises"), "having" (and any form of having,
15 such as "have" and "has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, unrecited elements or method steps

The term "or combinations thereof" as used herein refers to all permutations and
20 combinations of the listed items preceding the term. For example, "A, B, C, or combinations thereof" is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, MB, BBC, AAABCCCC,
25 CBBAAB, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

As a source of antibody gene segment sequences, the skilled person will also be aware of the following available databases and resources (including updates thereof) the
30 contents of which are incorporated herein by reference:

The Kabat Database (G. Johnson and T. T. Wu, 2002; World Wide Web (www.kabatdatabase.com)). Created by E. A. Kabat and T. T. Wu in 1966, the Kabat database publishes aligned sequences of antibodies, T-cell receptors, major histocompatibility

complex (MHC) class I and II molecules, and other proteins of immunological interest. A searchable interface is provided by the SeqhuntII

tool, and a range of utilities is available for sequence alignment, sequence subgroup classification, and the generation of variability plots. See also Kabat, E. A., Wu, T. T., Perry, H., Gottesman, K., and Foeller, C. (1991) *Sequences of Proteins of Immunological Interest*, 5th ed., NIH Publication No. 91-3242, Bethesda, MD, which is incorporated herein by reference, in particular with reference to human gene segments for use in the present invention.

KabatMan (A. C. R. Martin, 2002; World Wide Web (www)

bioinf.org.uk/abs/simkab.html). This is a web interface to make simple queries to the Kabat sequence database.

IMGT (the International ImMunoGeneTics Information System®; M.-P. Lefranc, 2002; World Wide Web (www) imgt.cines.fr). IMGT is an integrated information system that specializes in antibodies, T cell receptors, and MHC molecules of all vertebrate species.

It provides a common portal to standardized data that include nucleotide and protein sequences, oligonucleotide primers, gene maps, genetic polymorphisms, specificities, and two-dimensional (2D) and three-dimensional (3D) structures. IMGT includes three sequence databases (*IMGT/LIGM-DB*, *IMGT/MHC-DB*, *IMGT/PRIMERDB*), one genome database (*IMGT/GENE-DB*), one 3D structure database (*IMGT/3Dstructure-DB*), and a range of web resources ("*IMGT Marie-Paule page*") and interactive tools.

V-BASE (I. M. Tomlinson, 2002; World Wide Web (www) mrc-cpe.cam.ac.uk/vbase). V-BASE is a comprehensive directory of all human antibody germline variable region sequences compiled from more than one thousand published sequences. It includes a version of the alignment software DNAPLOT (developed by Hans-Helmar Althaus and Werner Müller) that allows the assignment of rearranged antibody V genes to their closest germline gene segments.

Antibodies—Structure and Sequence (A. C. R. Martin, 2002; World Wide Web (www) bioinf.org.uk/abs). This page summarizes useful information on antibody structure and sequence. It provides a query interface to the Kabat antibody sequence data, general information on antibodies, crystal structures, and links to other antibody-related information. It also distributes an automated summary of all antibody structures deposited in the Protein Databank (PDB). Of particular interest is a thorough description and comparison of the various numbering schemes for antibody variable regions.

AAAAA (A Ho's Amazing Atlas of Antibody Anatomy; A. Honegger, 2001; World Wide Web ([www](http://www.unizh.ch/~antibody)) unizh.ch/~antibody). This resource includes tools for structural analysis, modeling, and engineering. It adopts a unifying scheme for comprehensive structural alignment of antibody and T-cell-receptor sequences, and includes Excel macros for antibody analysis and graphical representation.

WAM (Web Antibody Modeling; N. Whitelegg and A. R. Rees, 2001; World Wide Web ([www](http://www.antibody.bath.ac.uk)) antibody.bath.ac.uk). Hosted by the Centre for Protein Analysis and Design at the University of Bath, United Kingdom. Based on the AbM package (formerly marketed by Oxford Molecular) to construct 3D models of antibody Fv sequences using a combination of established theoretical methods, this site also includes the latest antibody structural information.

Mike's Immunoglobulin Structure/Function Page (M. R. Clark, 2001; World Wide Web ([www](http://www.path.cam.ac.uk/~mrc7/mikeimages.html)) path.cam.ac.uk/~mrc7/mikeimages.html) These pages provide educational materials on immunoglobulin structure and function, and are illustrated by many colour images, models, and animations. Additional information is available on antibody humanization and Mike Clark's Therapeutic Antibody Human Homology Project, which aims to correlate clinical efficacy and anti-immunoglobulin responses with variable region sequences of therapeutic antibodies.

The Antibody Resource Page (The Antibody Resource Page, 2000; World Wide Web ([www](http://www.antibodyresource.com)) antibodyresource.com). This site describes itself as the "complete guide to antibody research and suppliers." Links to amino acid sequencing tools, nucleotide antibody sequencing tools, and hybridoma/cell-culture databases are provided.

Humanization bY Design (J. Saldanha, 2000; World Wide Web ([www](http://www.people.cryst.bbk.ac.uk/~ubcg07s)) people.cryst.bbk.ac.uk/~ubcg07s). This resource provides an overview on antibody humanization technology. The most useful feature is a searchable database (by sequence and text) of more than 40 published humanized antibodies including information on design issues, framework choice, framework back-mutations, and binding affinity of the humanized constructs.

See also Antibody Engineering Methods and Protocols, Ed. Benny K C Lo, *Methods in Molecular Biology*TM, Human Press. Also at World Wide Web ([www](http://www.blogsua.com/pdf/antibody-engineering-methods-and-protocolsantibody-engineering-methods-and-protocols.pdf)) blogsua.com/pdf/antibody-engineering-methods-and-protocolsantibody-engineering-methods-and-protocols.pdf

Any part of this disclosure may be read in combination with any other part of the disclosure, unless otherwise apparent from the context.

All of the compositions and/or methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred
5 embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the
10 art are deemed to be within the spirit, scope and concept of the invention as defined by the appended claims.

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to make and use the invention, and are not intended to limit the scope of what the inventors regard as their invention.

15 **Examples**

Example 1:

High Human Lambda Variable Region Expression in Transgenic Mice Comprising Human Lambda Gene Segments Inserted into Endogenous Kappa Locus

Insertion of human lambda gene segments from a 1st IGL BAC to the IGK locus of
20 mouse AB2.1 ES cells (Baylor College of Medicine) was performed to create a chimaeric light chain allele denoted the P1 allele (Fig.1). The inserted human sequence corresponds to the sequence of human chromosome 22 from position 23217291 to position 23327884 and comprises functional lambda gene segments V λ 3-1, J λ 1-C λ 1, J λ 2-C λ 2, J λ 3-C λ 3, J λ 6-C λ 6 and J λ 7-C λ 7 (the alleles of Table 13). The insertion was
25 made between positions 70674755 and 706747756 on mouse chromosome 6, which is upstream of the mouse C κ region and 3'E κ (ie, within 100kb of the endogenous light chain enhancer) as shown in Figure 1. The mouse V κ and J κ gene segments were retained in the chimaeric locus, immediately upstream of the inserted human lambda DNA. The mouse lambda loci were left intact. Mice homozygous for the chimaeric P1
30 locus were generated from the ES cells using standard procedures.

A second type of mice were produced (P2 mice) in which more human functional V λ gene segments were inserted upstream (5') of human V λ 3-1 by the sequential insertion

of the BAC1 human DNA and then BAC2 DNA to create the P2 allele (the alleles of table 14). The inserted human sequence from BAC2 corresponds to the sequence of human chromosome 22 from position 23064876 to position 23217287 and comprises functional lambda gene segments V λ 2-18, V λ 3-16, V λ 2-14, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8 and V λ 4-3. Mice homozygous for the chimaeric P2 locus were generated from the ES cells using standard procedures.

FACS analysis of splenic B cells from the P1 and P2 homozygotes was performed to assess lambda versus kappa expression and human lambda versus mouse lambda expression in the transgenic mice.

Standard 5'-RACE was carried out to analyse RNA transcripts from the light chain loci in P2 homozygotes.

Light Chain Expression & FACS Analysis

To obtain a single cell suspension from spleen, the spleen was gently passage through a 30 μ m cell strainer. Single cells were resuspended in Phosphate-Buffered Saline (PBS) supplemented with 3% heat inactivated foetal calf serum (FCS).

The following antibodies were used for staining:

Rat anti-mouse lambda (mC λ) phycoerythrin (PE) antibody (Southern Biotech), rat anti-mouse kappa (mC κ) (BD Pharmingen, clone 187.1) fluorescein isothiocyanate (FITC), anti-human lambda (hC λ) (eBioscience, clone 1-155-2) phycoerythrin (PE), anti-B220/CD45R (eBioscience, clone RA3-6B2) allophycocyanin (APC). NB: light chains bearing human C λ was expected to have variable regions derived from the rearrangement of inserted human V λ and human J λ . Light chains bearing mouse C λ was expected to have variable regions derived from the rearrangement of mouse V λ and J λ from the endogenous lambda loci.

5x10⁶ cells were added to individual tubes, spun down to remove excess of fluid, and resuspended in fresh 100 μ l of PBS + 3% FCS. To each individual tube the following antibodies were added:

For staining of m λ versus m κ 1 μ l of each antibody was added in addition to 1 μ l of B220/CD45R antibody. For detection of B cells expressing human lambda light chain, the m λ antibody was substituted with h λ antibody. Cells were incubated in the dark at 6^oC for 15 minutes followed by several washes with fresh PBS+3%FCS to remove unbound antibody. Cells were analysed using fluorescence-activated cell sorting

(FACS) analyser from Miltenyi Biotec.

Alive spleenocytes were gated using side scatter (SSC) and forward scatter (FSC).

Within the SSC and FSC gated population, a subpopulation of B220/CD45R (mouse B-cells) was detected using the APC fluorochrome. Single positive B220/CD45R

5 population was further subdivided into a cell bearing either m λ or h λ PE fluorochrome in conjunction with m κ FITC fluorochrome. The percentage of each population was calculated using a gating system.

Surprisingly, FACS analysis of splenic B cells from the P1 homozygotes showed no detectable mouse C κ expression (Fig. 2), indicating that insertion of the human lambda
10 locus DNA from BAC1 interrupts expression of the endogenous IGK chain.

The strong expression of endogenous C λ and weak expression of human C λ in the splenic B cells grouped by FACS analysis (mouse C λ : human C λ = 65: 32) in these mice suggest that inserted human IGL sequence, although interrupts the IGK activity, cannot totally compete with the endogenous IGL genes.

15 The FACS analysis again surprisingly showed no detectable mouse C κ expression in the P2 homozygotes (Figs. 3A & B). However, the human C λ greatly predominates in expressed B cells grouped as mouse or human C λ following FACS analysis (mouse C λ : human C λ = 15: 80 corresponding to a ratio of 15 mouse lambda variable regions: 80 human lambda variable regions, ie, 84% human lambda variable regions with reference
20 to the grouped B-cells – which corresponds to 80% of total B-cells) from the P2 homozygotes. While not wishing to be bound by any theory, we suggest that the inserted human lambda locus sequence from the 2nd BAC provides some advantages to compete with endogenous lambda gene segment rearrangement or expression.

We analysed human V λ and J λ usage in the P2 homozygotes. See Figure 4 which
25 shows the human V λ usage in P2 homozygotes. The observed usage was similar to that seen in humans (as per J Mol Biol. 1997 Apr 25;268(1):69-77; "The creation of diversity in the human immunoglobulin V(lambda) repertoire"; Ignatovich O *et al*). Further, the human J λ usage was similar to that seen in humans (Figure 5). The V λ versus V κ usage analysis of human C λ transcripts by sequencing of non-bias 5'-RACE (rapid amplification
30 of cDNA ends) PCR clones showed that among 278 clone sequences, only one used V κ for rearrangement to J λ (human J λ), and all others (277 clones) used human V λ (Figs. 6 & 7; V λ 2-5 was detected at the RNA transcript level, but this is a pseudogene which is usually not picked up by usage at the protein level). While not wishing to be bound by any theory, we suggest that the retained mouse V κ gene segments essentially cannot

efficiently rearrange with the inserted human J λ gene segments because they have the same type of RSSs (recombination signal sequences; see explanation below) and are incompatible for rearrangement (Fig. 8). This result also indicates that the inactivation of the endogenous IGK activity and predominate expression of the inserted human lambda sequence can be achieved without further modification of the IGK locus, for example, deletion or inversion of endogenous kappa loci gene segments is not necessary, which greatly simplifies the generation of useful transgenic mice expressing light chains bearing human lambda variable regions (ie, variable regions produced by recombination of human V λ and J λ gene segments).

- 10 The arrangement of recombination signal sequences (RSSs) that mediate V(D)J recombination *in vivo* is discussed, eg, in Cell. 2002 Apr;109 Suppl:S45-55; "The mechanism and regulation of chromosomal V(D)J recombination"; Bassing CH, Swat W, Alt FW (the disclosure of which is incorporated herein by reference). Two types of RSS element have been identified: a one-turn RSS (12-RSS) and a two-turn RSS (23-RSS).
- 15 In natural VJ recombination in the lambda light chain locus, recombination is effected between a two-turn RSS that lies 3' of a V lambda and a one-turn RSS that lies 5' of a J lambda, the RSSs being in opposite orientation. In natural VJ recombination in the kappa light chain locus, recombination is effected between a one-turn RSS that lies 3' of a V kappa and a two-turn RSS that lies 5' of a J kappa, the RSSs being in opposite
- 20 orientation. Thus, generally a two-turn RSS is compatible with a one-turn RSS in the opposite orientation.

Thus, the inventors have demonstrated how to (i) inactivate endogenous kappa chain expression by insertion of human lambda gene segments into the kappa locus; and (ii) how to achieve very high human lambda variable region expression (thus providing useful light chain repertoires for selection against target antigen) - even in the presence of endogenous lambda and kappa V gene segments. Thus, the inventors have shown how to significantly remove (lambda) or totally remove (kappa) V gene segment competition and thus endogenous light chain expression by the insertion of at least the functional human lambda gene segments comprised by BACs 1 and 2. In this example

25 a very high level of human lambda variable region expression was surprisingly achieved (84% of total lambda chains and total light chains as explained above).

30

Example 2:

High Human Lambda Variable Region Expression in Transgenic Mice Comprising Human Lambda Gene Segments Inserted into Endogenous Lambda Locus

Insertion of human lambda gene segments from the 1st and 2nd IGL BACs to the lambda locus of mouse AB2.1 ES cells (Baylor College of Medicine) was performed to create a lambda light chain allele denoted the L2 allele (Fig.1). The inserted human sequence corresponds to the sequence of human chromosome 22 from position 23064876 to position 23327884 and comprises functional lambda gene segments V λ 2-18, V λ 3-16, V2-14, V λ 3-12, V λ 2-11, V λ 3-10, V λ 3-9, V λ 2-8, V λ 4-3, V λ 3-1, J λ 1-C λ 1, J λ 2-C λ 2, J λ 3-C λ 3, J λ 6-C λ 6 and J λ 7-C λ 7. The insertion was made between positions 19047551 and 19047556 on mouse chromosome 16, which is upstream of the mouse C λ region and between E λ 4-10 and E λ 3-1 (ie, within 100kb of the endogenous light chain enhancers) as shown in Figure 1. The mouse V λ and J λ gene segments were retained in the locus, immediately upstream of the inserted human lambda DNA. The mouse kappa loci were inactivated to prevent kappa chain expression. Mice homozygous for the L2 locus were generated from the ES cells using standard procedures.

Using a similar method to that of Example 1, FACS analysis of splenic B cells from the L2 homozygotes was performed to assess lambda versus kappa expression and human lambda versus mouse lambda expression in the transgenic mice.

Light Chain Expression & FACS Analysis

The FACS analysis of splenic B-cells in L2 homozygotes under the IGK knockout background (in which V κ and J κ gene segments have been retained) surprisingly showed that expression of human C λ greatly predominates in B-cells grouped as mouse or human C λ following FACS analysis (mouse C λ : human C λ = 5: 93 corresponding to a ratio of 5 mouse lambda variable regions: 93 human lambda variable regions, ie, 95% human lambda variable regions with reference to the grouped B-cells – which corresponds to 93% of total B-cells) (Fig. 9A), demonstrating that inserted human IGL gene segments within the endogenous IGL locus can outcompete the endogenous IGL gene segment rearrangement or expression.

Thus, the inventors have demonstrated how to achieve very high human lambda variable region expression (thus providing useful light chain repertoires for selection against target antigen) – even in the presence of endogenous lambda and kappa V gene segments. Thus, the inventors have shown how to significantly remove endogenous lambda V gene segment competition and thus endogenous lambda light chain expression by the insertion of at least the functional human lambda gene segments comprised by BACs 1 and 2. In this example a very high level of human lambda variable region expression was surprisingly achieved (95% of total lambda chains and total light

chains as explained above).

These data indicate that mice carrying either P (Example 1) or L (Example 2) alleles produced by targeted insertion of the functional gene segments provided by BAC1 and BAC2 can function in rearrangement and expression in mature B cells. These two types
5 of alleles are very useful for providing transgenic mice that produce human Ig lambda chains for therapeutic antibody discovery and as research tools.

Transgenic Mice of the Invention Expressing Human Lambda Variable Regions Develop Normal Splenic Compartments

In spleen, B cells are characterized as immature (T1 and T2) and mature (M) based on
10 the levels of cell surface markers, IgM and IgD. T1 cells have high IgM and low IgD. T2 cells have medium levels of both them. M cells have low IgM but high IgD (figure 10).
See also J Exp Med. 1999 Jul 5;190(1):75-89; "B cell development in the spleen takes place in discrete steps and is determined by the quality of B cell receptor-derived signals"; Loder F *et al.*

15 Using methods similar to those described in Example 3 below, splenic B-cells from the animals were scored for IgD and IgM expression using FACS. We compared control mice KA/KA (in which endogenous kappa chain expression has been inactivated, but not endogenous lambda chain expression) with L2/L2;KA/KA mice (L2 homozygotes). The L2 homozygotes surprisingly showed comparable splenic B-cell compartments to the
20 control mice (Fig. 9B).

Example 3:

Assessment of B-Cell and Ig Development in Transgenic Mice of the Invention

We observed normal Ig subtype expression & B-cell development in transgenic mice of the invention expressing antibodies with human heavy chain variable regions
25 substantially in the absence of endogenous heavy and kappa chain expression.

Using ES cells and the RMCE genomic manipulation methods described above, mice were constructed with combinations of the following Ig locus alleles:-

S1F/HA, +/-KA = (i) S1F - first endogenous heavy chain allele has one human heavy chain locus DNA insertion, endogenous mouse VDJ region has been inactivated by
30 inversion and movement upstream on the chromosome (see the description above, where this allele is referred to as S1^{inv1}); (ii) HA – second endogenous heavy chain allele

has been inactivated (by insertion of an endogenous interrupting sequence); (iii) + - first endogenous kappa allele is a wild-type kappa allele and (iv) KA – the second endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence). This arrangement encodes exclusively for heavy chains from the first endogenous heavy chain allele.

S1F/HA, K2/KA = (i) K2 – the first endogenous kappa allele has two kappa chain locus DNA insertions between the most 3' endogenous Jk and the mouse Ck, providing an insertion of 14 human Vk and Jk1-Jk5; and (ii) KA – the second endogenous kappa allele has been inactivated (by insertion of an endogenous interrupting sequence). This arrangement encodes exclusively for heavy chains comprising human variable regions and substantially kappa light chains from the first endogenous kappa allele.

+/HA, K2/KA - this arrangement encodes for mouse heavy chains and human kappa chains.

+/HA, +/KA - this arrangement encodes for mouse heavy and kappa chains – the mice only produce mouse heavy and light chains.

In bone marrow, B progenitor populations are characterized based their surface markers, B220 and CD43. PreProB cells carry germline IGH and IGK/L configuration and have low B220 and high CD43 on their cell surface. ProB cells start to initiate VDJ recombination in the IGH locus and carry medium levels of both B220 and CD43. PreB cells carry rearranged IGH VDJ locus and start to initiate light chain VJ rearrangement, and have high B220 but low CD43. In spleen, B cells are characterized as immature (T1 and T2) and mature (M) based on the levels of cell surface markers, IgM and IgD. T1 cells have high IgM and low IgD. T2 cells have medium levels of both them. M cells have low IgM but high IgD (figure 10). See also J Exp Med. 1991 May 1;173(5):1213-25; "Resolution and characterization of pro-B and pre-pro-B cell stages in normal mouse bone marrow"; Hardy RR *et al* and J Exp Med. 1999 Jul 5;190(1):75-89; "B cell development in the spleen takes place in discrete steps and is determined by the quality of B cell receptor-derived signals"; Loder F *et al*.

Transgenic Mice of the Invention Develop Normal Splenic and BM Compartments

(a) Analysis of the Splenic Compartment

For each mouse, to obtain a single cell suspension from spleen, the spleen was gently passaged through a 30µm cell strainer. Single cells were resuspended in *Phosphate-*

Buffered Saline (PBS) supplemented with 3% heat inactivated foetal calf serum (FCS). 5×10^6 cells were added to individual tubes, spun down to remove excess of fluid and resuspended in fresh 100 μ l of PBS + 3% FCS. To each individual tube the following antibodies were added: anti-B220/CD45R (eBioscience, clone RA3-6B2)

- 5 allophycocyanin (APC), antibody against IgD receptor conjugated with phycoerythrin (PE) (eBioscience, clone 11-26) and antibody against IgM receptor conjugated with fluorescein isothiocyanate (FITC) (eBioscience, clone 11/41).

- For staining of IgM vs IgD, 5×10^6 cells were used for each staining. To each vial containing splenocytes a cocktail of antibodies was added consisting of: anti- IgD (PE),
10 anti-IgM (FITC) and anti-B220/CD45R (APC). Cells were incubated at 6°C for 15 minutes, washed to remove excess unbound antibodies and analysed using a fluorescence-activated cell sorting (FACS) analyser from Miltenyi Biotec. B-cells were gated as B220^{HIGH} IgM^{HIGH} IgD^{LOW} (ie, B220⁺ IgM⁺ IgD⁻) for T1 population, B220^{HIGH} IgM^{HIGH} IgD^{HIGH} (B220⁺ IgM⁺ IgD⁺) for T2 population and B220^{HIGH} IgM^{LOW} IgD^{HIGH} (B220⁺ IgM⁻ IgD⁺) for M population. Percentage of cells was calculated using gating system.
15 We used gates to identify and define subsets of cell populations on plots with logarithmic scale. Before gates are applied a single stain antibody for each fluorochrome is used to discriminate between a positive (high intensity fluorochrome) and negative (no detectable intensity fluorochrome) population. Gates are applied based on fluorochrome
20 intensities in the same manner to all samples. The single stains were:

IgD-PE

IgM-FITC

B220-APC

- 25 Alive splenocytes were gated using side scatter (SSC) and forward scatter (FSC). Within the SSC and FSC gated population, a subpopulation of B220/CD45R positive cells (mouse B-cells) was detected using the APC fluorochrome. The single positive B220/CD45R population was further subdivided into a cell bearing either IgM fluorescein isothiocyanate (FITC) or IgD fluorochrome in conjunction with m κ FITC fluorochrome.
30 The percentage of each population was calculated using gating system. The splenic B-Cell compartments in the mice of the invention are normal (ie, equivalent to the compartments of mice expressing only mouse antibody chains).

(b) Bone marrow B progenitor analysis

To obtain a single cell suspension from bone marrow for each mouse, the femur and tibia were flushed with *Phosphate-Buffered Saline* (PBS) supplemented with 3% heat inactivated foetal calf serum (FCS). Cells were further passage through a 30µm cell strainer to remove bone pieces or cell clumps. Cells were resuspended in cold PBS supplemented with 3% serum. 2×10^6 cells were added to individual tubes, spun down to remove excess of buffer, and resuspended in fresh 100µl of PBS + 3% FCS. To each individual tube the following antibodies were added: anti-Leukosialin (CD43) fluorescein isothiocyanate (FITC) (eBioscience, clone eBioR2/60) and anti-B220/CD45R (eBioscience, clone RA3-6B2) allophycocyanin (APC). Cells were incubated in the dark at 6°C for 15 minutes followed by several washes with fresh PBS+3%FCS to remove unbound antibody. Cells were analysed using a *fluorescence-activated cell sorting* (FACS) analyser from Miltenyi Biotec. Alive bone marrow cells were gated using side scatter (SSC) and forward scatter (FSC). We used gates to identify and define subsets of cell populations on plots with logarithmic scale. Before gates are applied a single stain antibody for each fluorochrome is used to discriminate between a positive (high intensity fluorochrome) and negative (no detectable intensity fluorochrome) population. Gates are applied based on fluorochrome intensities in the same manner to all samples. The single stains were:

B220-APC

CD43-FITC

Within the alive population a double population of B220/CD45R and CD43 positive cells was identified as a pre-B, pro-B and pre-pro B cells. The splenic B-Cell compartments in the mice of the invention are normal (ie, equivalent to the compartments of mice expressing only mouse antibody chains).

Transgenic Mice of the Invention Develop Normal Ig Expression

Quantification of serum IgM and IgG

96-well NUNC plates were coated initially with a capture antibody (goat anti-mouse Fab antibody at 1 µg/ml) overnight at 4°C). The IgG plates used anti-Fab, (M4155 Sigma) and the IgM plates used anti-Fab (OBT1527 AbD Serotec). Following three washes with phosphate buffer saline (PBS) containing 0.1% v/v Tween20, plates were blocked with 200 µl of PBS containing 1% w/v bovine serum albumin (BSA) for 1 hour at room

temperature (RT). The plates were washed three times as above and then 50 µl of standards (control mouse isotype antibodies, IgG1 (M9269 Sigma), IgG2a (M9144 Sigma), IgG2b (M8894 sigma), IgM (M3795 Sigma) or serum samples diluted in PBS with 0.1% BSA were added to each well, and incubated for 1 hour at RT. After washing
5 three times as above 100 µl of detection antibody (goat anti-mouse isotype specific antibody-horseradish peroxidase conjugated, 1/10000 in PBS with 0.1% Tween) (anti-mouse IgG1 (STAR132P AbD Serotec), anti-mouse IgG2a (STAR133P AdD Serotec), anti-mouse IgG2b (STAR134P AbD Serotec) and anti-mouse IgM (ab97230 Abcam) were added into each well and incubated for 1 hour at RT. The plates were washed
10 three times as above and developed using tetramethylbenzidine substrate (TMB, Sigma) for 4-5 minutes in the dark at RT. Development was stopped by adding 50 µl/well of 1 M sulfuric acid. The plates were read with a Biotek Synergy HT plate reader at 450 nm.

Conclusion:

Inversion of endogenous V_H -D- J_H following the human IGH BAC insertion results in
15 inactivation of rearrangement of endogenous V_H to inserted human D- J_H . The inventors observed, however, that surprisingly the inactivation of endogenous heavy chain expression does not change the ratio of B-cells in the splenic compartment (Fig. 11) or bone marrow B progenitor compartment (Fig. 12) and the immunoglobulin levels in serum are normal and the correct Ig subtypes are expressed (Fig. 13). This was shown
20 in mice expressing human heavy chain variable regions with mouse light chains (Figs 11A and 12A) as well as in mice expressing both human heavy chain variable regions and human light chain variable regions (Figs 11B and 12B). These data demonstrate that inserted human IGH gene segments (an insertion of at least human V_H gene segments V_H 2-5, 7-4-1, 4-4, 1-3, 1-2, 6-1, and all the human D and J_H gene segments
25 D1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 1-7, 2-8, 3-9, 5-12, 6-13, 2-15, 3-16, 4-17, 6-19, 1-20, 2-21, 3-22, 6-25, 1-26 and 7-27; and J1, J2, J3, J4, J5 and J6) are fully functional in the aspect of rearrangement, BCR signalling and B cell maturation. Functionality is retained also when human light chain VJ gene segments are inserted to provide transgenic light chains, as per the insertion used to create the K2 allele. This insertion is an insertion
30 comprising human gene segments V_k 2-24, V_k 3-20, V_k 1-17, V_k 1-16, V_k 3-15, V_k 1-13, V_k 1-12, V_k 3-11, V_k 1-9, V_k 1-8, V_k 1-6, V_k 1-5, V_k 5-2, V_k 4-1, J_k 1, J_k 2, J_k 3, J_k 4 and J_k 5. Greater than 90% of the antibodies expressed by the S1F/HA; K2/KA mice comprised human heavy chain variable regions and human kappa light chain variable regions. These mice are, therefore, very useful for the selection of antibodies having human
35 variable regions that specifically bind human antigen following immunisation of the mice with such antigen. Following isolation of such an antibody, the skilled person can

replace the mouse constant regions with human constant regions using conventional techniques to arrive at totally human antibodies which are useful as drug candidates for administration to humans (optionally following mutation or adaptation to produce a further derivative, eg, with Fc enhancement or inactivation or following conjugation to a toxic payload or reporter or label or other active moiety).

A further experiment was carried out to assess the IgG and IgM levels and relative proportions in transgenic mice of the invention that express antibodies that have human heavy and light (kappa) variable regions (S1F/HA, K2/KA mice; n=15). These were compared against 12 mice expressing only mouse antibody chains (+/HA, +/KA (n=6) and wild-type mice (WT; n=6)). The results are tabulated below (Table 19) and shown in Figure 14.

It can be seen that the mice of the invention, in which essentially all heavy chain variable regions are human heavy chain variable regions, expressed normal proportions of IgM and IgG subtypes, and also total IgG relative to IgM was normal.

Table 19:

	IgG1 (µg/mL)	IgG2a (µg/mL)	IgG2b (µg/mL)	IgM (µg/mL)	Total IgG + IgM (µg/mL)
KMCB22.1a S1F/HA, K2/KA	30.5	38.3	49.9	1.7 2 2 4 . 4	1.8 343.1
KMCB 19.1d S1F/HA, K2/KA	103.6	181.2	85.6	1.9 3 5 1 . 7	1.10 722.1
KMCB 19.1h S1F/HA, K2/KA	191.4	456.6	383.3	1.11 6 4 3 . 2	1.12 1674.6

KMCB 20.1a S1F/HA, K2/KA	53.6	384.4	249.7	1.13 4 2 7 .1	1.14 1114.7
KMCB 20.1c S1F/HA, K2/KA	87.3	167.0	125.7	1.15 4 2 2 .1	1.16 802.1
KMCB 20.1f S1F/HA, K2/KA	55.4	177.2	95.6	1.17 2 9 5 .7	1.18 623.9
KMCB22.1f S1F/HA, K2/KA	61.1	56.3	111.4	1.19 2 4 5 .8	1.20 474.5
KMCB23.1c S1F/HA, K2/KA	71.4	70.7	80.5	1.21 5 8 5 .4	1.22 808.0
KMCB23.1d S1F/HA, K2/KA	65.4	148.7	187.4	1.23 2 5 5 .4	1.24 657.0

KMCB24.1f S1F/HA, K2/KA	60.0	56.6	150.5	1.25 2 9 4 .8	1.26 561.9
KMCB13.1a S1F/HA, K2/KA	101.2	200.5	269.8	1.27 1 4 4 .1	1.28 715.7
KMCB13.1d S1F/HA, K2/KA	124.5	117.5	246.6	1.29 1 8 3 .2	1.30 671.9
KMCB17.1f S1F/HA, K2/KA	58.3	174.2	1.31 11 6.2	1.32 2 1 8 .1	1.33 566.8
KMCB14.1a S1F/HA, K2/KA	51.9	46.5	27.9	1.34 2 2 2 .2	1.35 348.6
KMCB14.1b S1F/HA, K2/KA	11.5	54.2	48.5	1.36 1 9 4 .4	1.37 308.6

KMCB19.1e +/-HA, +/KA	233.0	6.7	465.6	1.38 4 2 0 9	1.39 1126.3
KMCB19.1f +/-HA, +/KA	154.3	4.6	610.2	1.40 4 3 5 7	1.41 1204.8
KMCB19.1l +/-HA, +/KA	113.5	1.1	246.8	1.42 3 7 4 6	1.43 736.0
KMCB20.1e +/-HA, +/KA	561.0	4.3	614.3	1.44 4 8 2 1	1.45 1661.7
KMCB13.1e +/-HA, +/KA	439.3	17.1	584.1	1.46 1 9 6 9	1.47 1237.3
KMCB14.1c +/-HA, +/KA	93.4	1.3	112.0	1.48 1 0 6 8	1.49 313.6

KMWT 1.3c WT	212.9	155.2	104.6	1.50 2 3 3 . 7	1.51 706.4
KMWT 1.3d WT	297.1	203.2	144.6	1.52 2 4 8 . 6	1.53 893.5
KMWT 1.3e WT	143.1	174.2	619.1	1.54 2 5 1 . 8	1.55 1188.2
KMWT 1.3f WT	218.8	86.8	256.1	1.56 2 9 4 . 8	1.57 856.4
KMWT 1.3b WT	150.2	114.2	114.7	1.58 2 2 5 . 6	1.59 604.7
KMWT 3.1e WT	125.9	335.5	174.6	1.60 2 4 8 . 9	1.61 884.9

Example 4:

Assessment of Kappa : Lambda Ratio & Splenic B-cell Compartments in Transgenic Mice of the Invention

Mice comprising the following genomes were obtained.

WT/WT = wild-type;

- 5 KA/KA = each endogenous kappa allele has been inactivated; and the endogenous lambda loci are left intact;

K3F/K3F = each endogenous kappa allele has three kappa chain locus DNA insertions between the 3' most endogenous J_K and the mouse C_K, providing insertion of human V gene segments V_K2-40, V_K1-39, V_K1-33, V_K2-30, V_K2-29, V_K2-28, V_K1-27, V_K2-24, V_K3-20, V_K1-17, V_K1-16, V_K3-15, V_K1-13, V_K1-12, V_K3-11, V_K1-9, V_K1-8, V_K1-6, V_K1-5, V_K5-2 and V_K4-1 and human J gene segments J_K1, J_K2, J_K3, J_K4 and J_K5 (the human V gene segments being 5' of the human J gene segments); each endogenous kappa VJ has been inactivated by inversion and movement upstream on the chromosome; and the endogenous lambda loci are left intact;

- 15 L2/L2 = as described in Example 2 (L2 homozygotes where human lambda variable region DNA has been inserted into the endogenous lambda loci; the endogenous kappa loci are left intact);

L2/L2;KA/KA = as L2/L2 but the endogenous kappa alleles have been inactivated (by insertion of an endogenous interrupting sequence=KA);

- 20 L3/L3;KA/KA = as L2/L2;KA/KA but supplemented by a third human lambda variable region DNA insertion 5' of the second lambda DNA insertion in the endogenous lambda loci such that the following human lambda gene segments are inserted between 3' most endogenous J_λ and the mouse C_λ: human V gene segments V_λ3-27, V_λ3-25, V_λ2-23, V_λ3-22, V_λ3-21, V_λ3-19, V_λ2-18, V_λ3-16, V_λ2-14, V_λ3-12, V_λ2-11, V_λ3-10, V_λ3-9, V_λ2-8, V_λ4-3 and V_λ3-1, human J and C gene segments J_λ1-C_λ1, J_λ2-C_λ2, J_λ3-C_λ3, J_λ6-C_λ6 and J_λ7-C_λ7 (non-functional segments J_λ4-C_λ4, J_λ5-C_λ5 were also included), thus providing an insertion corresponding to coordinates 22886217 to 23327884 of human chromosome 22 inserted immediately after position 19047551 on mouse chromosome 16;

- 30 S3F/HA;KA/KA;L3/L3 = first endogenous heavy chain allele has three human heavy chain variable region DNA insertions between the 3' most endogenous J_H and the E_μ, providing insertion of human gene segments V_H2-26, V_H1-24, V_H3-23, V_H3-21, V_H3-20,

V_H1-18, V_H3-15, V_H3-13, V_H3-11, V_H3-9, V_H1-8, V_H3-7, V_H2-5, V_H7-4-1, V_H4-4, V_H1-3, V_H1-2, V_H6-1, D1-1, D2-2, D3-9, D3-10, D4-11, D5-12, D6-13, D1-14, D2-15, D3-16, D4-17, D5-18, D6-19, D1-20, D2-21, D3-22, D4-23, D5-24, D6-25, D1-26, D7-27, J_H1, J_H2, J_H3, J_H4, J_H5 and J_H6 (in the order: human V gene segments, human D gene segments and human J gene segments); the endogenous heavy chain VDJ sequence has been inactivated by inversion and movement upstream on the chromosome; and the endogenous lambda loci are left intact; the second endogenous heavy chain allele has been inactivated by insertion of an endogenous interrupting sequence = HA); the endogenous kappa alleles have been inactivated (=KA/KA); and the endogenous lambda alleles have been modified by insertion of human lambda variable region DNA (=L3/L3);

P2/WT = P2 allele (human lambda variable region DNA as described in Example 1) at one endogenous kappa locus; the other endogenous kappa locus left intact; both endogenous lambda loci left intact;

P2/P2 = see Example 14; both endogenous lambda loci left intact;

P2/K2 = P2 allele at one endogenous kappa locus; the other endogenous kappa locus having two DNA insertions between the 3' most endogenous J_k and the mouse C_k, providing insertion of human V gene segments V_k2-24, V_k3-20, V_k1-17, V_k1-16, V_k3-15, V_k1-13, V_k1-12, V_k3-11, V_k1-9, V_k1-8, V_k1-6, V_k1-5, V_k5-2 and V_k4-1 and human J gene segments J_k1, J_k2, J_k3, J_k4 and J_k5 (the human V gene segments being 5' of the human J gene segments); both endogenous lambda loci left intact;

P3/K3F = as one endogenous kappa locus having an insertion between the following human lambda gene segments are inserted between the 3' most endogenous J_k and the mouse C_k, providing insertion of human V gene segments V_λ3-27, V_λ3-25, V_λ2-23, V_λ3-22, V_λ3-21, V_λ3-19, V_λ2-18, V_λ3-16, V_λ2-14, V_λ3-12, V_λ2-11, V_λ3-10, V_λ3-9, V_λ2-8, V_λ4-3 and V_λ3-1, human J and C gene segments J_λ1-C_λ1, J_λ2-C_λ2, J_λ3-C_λ3, J_λ6-C_λ6 and J_λ7-C_λ7 (non functional segments J_λ4-C_λ4, J_λ5-C_λ5 were also included), thus providing an insertion corresponding to coordinates 22886217 to 23327884 of human chromosome 22 inserted immediately after position 70674755 on mouse chromosome 6; the other endogenous kappa locus having the K3F allele described above (human V and J kappa gene segments inserted); both endogenous lambda loci left intact;

P2/P2; L2/WT = As P2/P2 but wherein one endogenous lambda locus has the L2 allele (human lambda V and J gene segments inserted) and the other endogenous lambda locus is wild-type; and

P2/P2; L2/L2 = homozygous for P2 and L2 alleles at endogenous kappa and lambda loci respectively.

FACS analysis of splenic B-cells (as described above) was carried out and proportions of light chain expression were determined. We also determined the proportions of T1, T2 and mature (M) splenic B-cells and compared with wild-type mice, in order to assess whether or not we obtained normal splenic B-cell compartments in the transgenic mice. The results are shown in Tables 20 and 21. We also assessed the proportion of B220 positive cells as an indication of the proportion of B-cells in the splenic cell samples.

Table 20: Comparisons With Mice With Human Lambda Variable Region Inserts At Endogenous Lambda Locus

Genotype	B220	IGL percentage			Splenic B-cell compartment		
		1.62 m I G K	1.63 m I G λ	1.64 h I G λ	T1	T2	M
WT/WT (n=2)	20%	90%	3.80%	1.65	1.66 1 6 %	1.67 1 6 5	1.68 5 7 . 5 0 %
KA/KA (n=2)	13.60%	0.28%	68.50%	1.69 0 %	1.70 3 3 %	1.71 9 %	1.72 4 1 %
K3F/K3F (n=2)	20%	83%	7%	1.73	1.74 1 6 %	1.75 1 5 . 5 0 %	1.76 5 8 %

L2/L2 (n=2)	17.80%	91.60%	1.60%	1.77 6 5 0 %	1.78 2 1 5 0 %	1.79 1 0 %	1.80 5 0 %
L2/L2;KA/KA (n=1)	9.10%	0%	5%	1.81 9 3 %	1.82 2 8 %	1.83 7 %	1.84 4 4 %
L3/L3;KA/KA (n=2)	16.90%	0.10%	4.50%	1.85 9 3 2 0 %	1.86 1 7 4 0 %	1.87 1 3 1 0 %	1.88 5 3 9 0 %
S3F/HA;KA/K; L3/L3 (n=1)	19%	0.20%	3.80%	1.89 9 8 %	1.90 1 5 5 0 %	1.91 1 9 %	1.92 5 3 2 0 %

Table 21: Mice With Human Lambda Variable Region Inserts At Endogenous Kappa Locus

Genotype	B220	IGL Percentage			Splenic B-cell compartment		
		1.93 m I G κ	1.94 m I G λ	1.95 hI G λ	T1	T2	M
P2/WT	N.D	90%	4.20%	1.96 6.	1.97 1	1.98 8.	1.99 52.

(n=2)				5 5 %	7 . 3 0 %	9 0 %	50 %
P2/P2 (n=2)	14.80%	0.20%	15%	1.100 7 6 %	1.101 2 7 . 5 0 %	1.102 1 2 %	1.103 42 %
P2/K2 (n=2)	18.20%	78.80%	7.90%	1.104 1 5. 6 0 %	1.105 1 9 . 5 0 %	1.106 1 2 %	1.107 50 %
P3/K3F (n=2)	18.40%	64.80%	11.60%	1.108 1 9. 4 0 %	1.109 1 1 . 8 0 %	1.110 1 8. 4 0 %	1.111 56. 10 %
P2/P2; L2/WT (n=2)	20.40%	0.05%	8.50%	1.112 9 4 %	1.113 1 3 . 1 0 %	1.114 1 6. 1 0 %	1.115 59. 90 %
P2/P2; L2/L2 (n=2)	12.70%	0.07%	5.10%	1.116 9 5. 4 0	1.117 1 3 . 4	1.118 1 3. 8 0	1.119 57. 30 %

				%	0 %	%	
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Conclusions

As demonstrated by L2/L2;KA/KA and L3/L3;KA/KA, the human lambda variable region DNA insertions at the endogenous lambda locus (with an endogenous kappa knockout) displayed predominate expression of light chains bearing human lambda variable regions (indicated by the expression of C λ -positive chains at around 93%). This surprisingly occurs even though endogenous mouse lambda variable region DNA is still present, indicating that the inserted human lambda variable region DNA can outcompete endogenous IG λ rearrangement.

Furthermore, mice having the human V and J gene segments present in the homozygous L3 insertion produce B-cells (B220 positive cells) at a proportion that is similar to wild-type and additionally produce a normal proportion or percentage of mature splenic B-cells (ie, similar to wild-type). This is confirmed not only by the L3/L3;KA/KA mice, but also was observed for S3F/HA;KA/KA;L3/L3, which also comprises a chimaeric (human-mouse) IgH locus.

Also, we observed that mice having the human V and J gene segments present in the homozygous K3F insertion produce B-cells (B220 positive cells) at a proportion that is similar to wild-type and additionally produce a normal proportion or percentage of mature splenic B-cells (ie, similar to wild-type).

Mice having the human V and J gene segments present in the homozygous P2 insertion at the endogenous kappa locus showed high expression of light chains comprising human lambda variable regions (as indicated by an observed proportion of 76%). We could skew to an even higher percentage overall by combining insertion of human lambda V and J gene segments at both the endogenous kappa and lambda loci (see P2/P2; L2/WT at around 94% and P2/P2; L2/L2 at around 95%). Furthermore, mice comprising the human V and J gene segment arrangement of P2/P2; L2/L2 produce a normal proportion or percentage of mature splenic B-cells (ie, similar to wild-type).

When human lambda V and J gene segments were inserted at one endogenous kappa locus and the other endogenous kappa locus comprised an insertion of human kappa V and J gene segments, we obtained mice that could express light chains comprising

lambda variable regions and also light chains comprising kappa variable regions.

Surprisingly observed that we could raise the proportion of light chains comprising lambda variable regions above that seen in a wild-type mouse where only 5% or less of light chains typically comprise lambda variable regions. We observed a proportion of around 22% for the P2/K2 genotype and around 31% for the P3/K3F genotype. The proportion observed with the latter genotype approximates that seen in a human where typically around 60% of light chains comprise kappa variable regions and around 40% of light chains comprise lambda variable regions. Also in the P2/K2 and P3/K3F cases, the mice produced a normal proportion of B-cells as compared with wild-type mice.

Furthermore, mice comprising the human V and J gene segment arrangement of P3/K3F produce a normal proportion or percentage of mature splenic B-cells (ie, similar to wild-type).

Example 5:

Mouse were generated that comprised the specific IgH alleles listed in Table 3; and the specific IgL alleles listed in Tables 10 or 11. Mice were immunised with target antigens and antigen-specific antibodies were isolated. Antibodies were assessed for binding specificity, maturation (ie, extent of junctional and somatic mutation versus germline gene segment sequences) and binding kinetics. Corresponding B-cells were also obtained and in some cases hybridomas produced that express the selected antibodies.

Selected antibodies are summarised in Table 22. Binding kinetics of some of these were determined as follows.

Binding Kinetics Determination

An anti-mouse IgG capture surface was created on a GLM Biosensor™ chip by primary amine coupling using GE Healthcare anti-mouse IgG (BR-1008-38). Test antibodies as set out in Table 22 were captured on this surface and the respective antigen was passed over the captured Ab at the concentrations indicated. An injection of buffer (i.e. 0nM of antigen) was used to double reference the binding curves, and the data was fitted to the 1:1 model inherent to the ProteOn XPR36™ analysis software. Regeneration of the capture surface was carried out using 10mM glycine, pH1.7. The assay was run at 25°C and using HBS-EP as running buffer.

Target 1: a multi-subunit human protein

Target 2: a bacterial cytotoxin

Target 3: a different multi-subunit human protein

Target 4: a protein expressed as a transmembrane protein on human cells

Target 1 mAb1.1

Single concentration TARGET 1 (256nM), anti-mouse capture

5	ka	kd	KD
	3.85E+05	3.22E-05	83pM

(Apparent affinity since multi-subunit target)

Target 2 mAb2.1

TARGET 2 at 256, 64, 16, 4 and 1 nM; results of 3 experiments:-

10 Experiment 1:

	ka	kd	KD
	1.40E+04	1.83E-05	1.300nM

Experiment 2:

	ka	kd	KD
15	2.76E+04	3.23E-05	1.170

Experiment 3:

Couldn't resolve off-rate – indicating extremely tight binding beyond detectable limits.

Target 3 mAb3.1

TARGET 3 at 256, 64, 16, 4 and 1 nM

20	ka	kd	KD
	4.00E+05	2.34E-04	0.59nM

(Apparent affinity since multi-subunit target)

Target 3 mAb3.2

TARGET 3 at 256, 64, 16, 4 and 1 nM

ka	kd	KD
3.86E+05	2.57E-04	0.67

(Apparent affinity since multi-subunit target)

5 **Target 3 mAb3.3**

TARGET 3at 256, 64, 16, 4 and 1 nM

ka	kd	KD
----	----	----

Unable to resolve Off-rate, extremely tight binding

(Apparent affinity since multi-subunit target)

- 10 In conclusion, the present invention provides for *in vivo* affinity-matured antibodies with human variable domains that can expressed in *in vivo* systems, and specifically bind target antigens with very good affinities, on and off-rates. The invention thus provides for antibodies that are useful for human medicine, as well as non-human vertebrates, cells (eg, B-cells and hybridomas) for producing such antibodies.

15 **Example 6:**

- The S (heavy), K(kappa into kappa locus), L (lambda into lambda locus) and P (lambda into kappa locus) lines used to generate the data in the examples used the alleles of Tables 1 to 18 and demonstrated that such collections of alleles can produce the surprising results shown (eg, good B cell compartments, high human lambda V region expression, desirable lambda:kappa ratio in a mouse and normal repertoire of IgH isotypes). The isolated antibodies were all based on the alleles listed in Table 1 to 18 above. All had V domains with mouse AID and TdT pattern mutation.
- 20

Other Embodiments

From the foregoing description, it will be apparent that variations and modifications may be made to the invention described herein to adopt it to various usages and conditions. Such embodiments are also within the scope of the following
5 claims.

The recitation of a listing of elements in any definition of a variable herein includes definitions of that variable as any single element or combination (or subcombination) of listed elements. The recitation of an embodiment herein includes that embodiment as any single embodiment or in combination with any other embodiments or
10 portions thereof.

All publications and patent applications mentioned in the specification are indicative of the level of skill of those skilled in the art to which this invention pertains. All publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and
15 individually indicated to be incorporated by reference.

Table 22

Hybridoma												
ma												
Sequences												
ces												
TARGE							AAMutations ²		nonGermLineAA ¹			
T 1:	v	d	j	1.120	1.121	1.122	kv	1.123	1.124	1.125		
mAb1.1	IGHV7			1.126	2	1.127	1.128	IGK	1.130	1.131		
	-4- IGHJ6						V2- 1.129 IGK					
	IGHD3 IGHJ6						28* J4*					
mAb1.2	1*01	-16*02	*02	1.132	3	1.133	01	1	1.136	1.137		
	IGHV4						1.134 IGK					
	IGHD3 IGHJ6						V1D					
TARGE	-4*02			1.132	0	1.133	-	1.135 IGK	1.136	1.137		
	IGHD3 IGHJ6						13* J4*					
	-10*01						d01	1				

T 2:

mAb2.1	IGHV1 -3*01	IGHD3 -10*01	IGHJ6 *02	1.138	6	1.139	9	1.140	IGK	1.141	IGK	1.143	0
								V1-					
								12*		J4*			
								01	1	1.142	1		

TARGE

T 3:

mAb3.1	IGHV3 -13*01	IGHD3 -9*01	IGHJ6 *02	1.144	3	1.145	5	1.146	IGK	1.147	IGK	1.149	4
								V1D					
								-		J4*			
								12*	02	1	1.148	0	
mAb3.2	IGHV3 -13*01	IGHD3 -9*01	IGHJ6 *02	1.150	3	1.151	5	1.152	IGK	1.153	IGK	1.155	4
								V1D					
								-		J4*			
								12*	02	1	1.154	0	
mAb3.3	IGHV4 -4*02	IGHD3 -10*01	IGHJ6 *02	1.156	2	1.157	7	1.158	IGK	1.159	IGK	1.161	3
								V1D		J4*	1.160	3	

- 1
13*
d01

BcellTe
ch
Sequen
ces

TARGE
T 1:

id	v	d	j	1.162	nonGermI ineAA ¹	1.163	AAMuta tions ²	1.164	kv	1.165	kj	1.166	knonGerm lineAA ¹	1.167	kAAMut ations ²
mAb1.3	IGHV3	IGHD3	IGHJ6					1.170	IGK						
	-13*01	-10*01	*02	1.168	5	1.169	0								
									V3-	1.171	IGK				
									20*		J4*				
									01		1	1.172	0	1.173	0

TARGE
T 3:

id	v	d	j	1.174		1.175		AAMuta		1.176		1.177		1.178		1.179		kAAMuta ations ²
				nonGermI ineAA ¹	tions ²	1.176 kv	1.177 kj	1.178	knonGerm lineAA ¹	1.179								
mAb3.4	IGHV3	IGHD3	IGHJ6	-23*04	-22*01	*02	1.180	9	1.181	8	1.182	IGK	1.183	IGK	1.184	1	1.185	1
											V1-	J4*						
											17*	1						
mAb3.5	IGHV3	IGHD3	IGHJ6	-23*04	-22*01	*02	1.186	10	1.187	5	1.188	IGK	1.189	IGK	1.190	1	1.191	0
											V1-	J4*						
											17*	1						
mAb3.6	IGHV3	IGHD3	IGHJ6	-7*01	-9*01	*02	1.192	6	1.193	2	1.194	IGK	1.195	IGK	1.196	2	1.197	3
											V1D	J4*						
											-	39*		1				
mAb3.7	IGHV3	IGHD3	IGHJ6	-23*04	-22*01	*02	1.198	9	1.199	5	1.200	IGK	1.201	IGK	1.202	1	1.203	1
											V1D	J4*						
											-	39*		1				

-23*04 -22*01 *02									
mAb3.8	IGHV3	IGHD3	IGHJ6	IGHV3	IGHD3	IGHJ6	IGHV3	IGHD3	IGHJ6
mAb3.9	IGHV3	IGHD3	IGHJ6	IGHV3	IGHD3	IGHJ6	IGHV3	IGHD3	IGHJ6
TARGE									
T 4:									
mAb4.1	IGHV4	IGHD3	IGHJ6	IGHV4	IGHD3	IGHJ6	IGHV4	IGHD3	IGHJ6
mAb4.2	IGHV4	IGHD3	IGHJ6	IGHV4	IGHD3	IGHJ6	IGHV4	IGHD3	IGHJ6
id v d j									
nonGermI AAMuta									
1.216 1.217 1.220 1.221									
ineAA ¹ tions ² kv 1.219 kj lineAA ¹ kAAMut									
1.222 7 1.223 7 1.224 IGK 1.225 IGK 1.226 1 1.227 1									
-4*02 -9*01 *02									
J4*									
1.206 IGK 1.207 IGK 1.208 2 1.209 4									
V1D - 39* 01 1 1.212 IGK 1.213 IGK 1.214 0 1.215 5									
V1D - 39* 01 1 1.212 IGK 1.213 IGK 1.214 0 1.215 5									

Sequences for examples of gene segments in accordance with the invention are set out below.

IGLC7*01

ggtcagcccaaggctgccccctcggctactctgttcccacctcctctgaggagcttcaa
gccaacaaggccacactggtgtgtctcgttaagtgacttctacccgggagccgtgacagt
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caaagcaacaacaagtatgcggccagcagctacctgagcctgacgcccagcagtggaag
tcccacagaagctacagctgccgggtcacgcatgaaggagcaccgtggagaagacagt
gccccgcagaatgctct

IGLJ7*01

tgtgtgttcggaggaggcaccagctgaccgtcctcg

IGLC6*01

ggtcagcccaaggctgccccatcggctactctgttcccgccctcctctgaggagcttcaa
gccaacaaggccacactggtgtgcctgatcagtgacttctacccgggagctgtgaaagt
gcctggaaggcagatggcagccccgtcaacacgggagtgagaccaccacacctccaaa
cagagcaacaacaagtacgcggccagcagctacctgagcctgacgctgagcagtggaag
tcccacagaagctacagctgccaggtcacgcatgaaggagcaccgtggagaagacagt
gccccgcagaatgttca

IGLC6*04

gtcagcccaaggctgccccatcggctactctgttcccgccctcctctgaggagcttcaag
ccaacaaggccacactggtgtgcctgatcagtgacttctacccgggagctgtgaaagt
cctggaaggcagatggcagccccgtcaacacgggagtgagaccaccacacctccaaac
agagcaacaacaagtacgcggccagcagctagctacctgagcctgacgctgagcagtg
aagtcccacagaagctacagttgccaggtcacgcatgaaggagcaccgtggagaagaca
gtggccccgcagaatgctct

IGLJ6*01

taatgtgttcggcagtgccaccaaggtagccgtcctcg

IGLC3*03

ggtcagcccaaggctgccccctcggctactctgttcccacctcctctgaggagcttcaa
gccaacaaggccacactggtgtgtctcataagtgacttctacccgggagccgtgacagt
gcctggaaggcagatagcagccccgtcaaggcgggagtgagaccaccacacctccaaa
caaagcaacaacaagtacgcggccagcagctacctgagcctgacgctgagcagtggaag
tcccacaaaagctacagctgccaggtcacgcatgaaggagcaccgtggagaagacagt
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IGLJ3*02

ttgggtgttcggcggaggaggaccaagctgaccgtcctag

IGLC2*02

ggtcagcccaaggctgccccctcggtcactctgttcccgccctcctctgaggagcttcaa
gccaacaaggccacactgggtgtgtctcataagtgacttctacccgggagccgtgacagt
gcctggaaggcagatagcagccccgtcaaggcgaggagtgagaccaccacacccctccaaa
caaagcaacaacaagtacgcggccagcagctatctgagcctgacgcctgagcagtggaag
tcccacagaagctacagctgccaggtcacgcatgaaggagcaccgtggagaagacagt
gcccctacagaatgttca

IGLJ2*01

tgtggtattcggcggagggaaccaagctgaccgtcctag

IGLC1*02

ggtcagcccaaggccaacccactgtcactctgttcccgccctcctctgaggagctcaa
gccaacaaggccacactagtgtgtctgatcagtgacttctacccgggagctgtgacagt
gcctggaaggcagatggcagccccgtcaaggcgaggagtgagaccaccaaaccctccaaa
cagagcaacaacaagtacgcggccagcagctacctgagcctgacgcccagcagtggaag
tcccacagaagctacagctgccaggtcacgcatgaaggagcaccgtggagaagacagt
gcccctacagaatgttca

IGLJ1*01

ttatgtcttcggaactgggaccaaggtcaccgtcctag

IGLV3-1*01

gatccgtggcctcctatgagctgactcagccaccctcagtgccgtgtcccaggacagacagccagc
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ggccagtcccctgtgctggtcatctatcaagatagcaagcgccctcagggatccctgag
cgattctctggctccaactctgggaacacagccactctgaccatcagcgggacccaggct
atggatgaggctgactattactgtcaggcgtgggacagcagcactgca

IGLV4-3*01

ctgcctgtgctgactcagccccgtctgcatctgccttctgtgggagcctgatcaagctcacc
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atccccgatcgctcatgggtccagttctggggctgaccgctacctcaccttctccaac
ctccagtctgacgatgaggctgagtatcactgtggagagagccacacgattgatggcaa
gtcgggtgagc

IGLV2-8*01

cagtctgccctgactcagcctccctccgctccgggtctcctggacagtcagtcaccatctcctgactgga
accagcagtgacgttggtggtataactatgtctcctggtaccaacagcaccaggcaaa
gccccaaactcatgatttatgaggtcagtaagcgccctcaggggtccctgatcgcttc
tctggctccaagtctggcaacaggcctccctgaccgtctctgggtccaggctgaggat
gaggctgattattactgcagctcatatgcaggcagcaacaatttc

IGLV3-9*01

tcctatgagctgactcagccactctcagtgctcagtgccctgggacagacggccaggattacc
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gcccctgtgctggtcatctatagggatagcaaccggccctctgggatccctgagcgattc
tctggctccaactcggggaacacggccaccctgaccatcagcagagcccaagccggggat
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IGLV3-10*01

tcctatgagctgacacagccaccctcggtgtcagtgctcccaggacaaaacggccaggatcacc
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tctggctccagctcagggacaatggccacctgactatcagtggggcccagggtggaggat
gaagctgactactactgttactcaacagacagcagtggtaatcatag

IGLV2-11*01

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ccaggcaaagccccaaaactcatgatttatgatgtcagtaagcgccctcaggggtccct
gatcgcttctctggctccaagtctggcaacacggcctccctgaccatctctgggctccag
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IGLV3-12*02

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gaccctgtgctggtcatctatagcgatagcaaccggccctcagggatccctgagcgattc
tctggctccaaccaggggaacaccgccaccctaaccatcagcaggatcgaggctggggat
gaggctgactattactgtcaggtgtgggacagtagtagtgatcatcc

IGLV2-14*01

cagtctgccctgactcagcctcgctccgtgtctgggtctcctggacagtcgatcaccatctcc
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ccaggcaaagccccaaaactcatgatttatgaggtcagtaatcgccctcaggggttct
aatcgcttctctggctccaagtctggcaacacggcctccctgaccatctctgggctccag
gctgaggacgaggctgattattactgcagctcatatacaagcagcagcactctc

IGLV3-16*01

tcctatgagctgacacagccaccctcggtgtcagtgctccctaggacagatggccaggatcacc
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IGLV2-18*01

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IGLV3-19*01

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IGLV3-21*01

tcctatgtgtgactcagccaccctcagtgctcagtggtggcccaggaaagacggccaggattacc
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IGLV3-21*d01

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IGLV3-22*d01

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IGLV3-22*01

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IGLV2-23*d02

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aatcgcttctctggctccaagtctggcaacacggcctccctgacaatctctgggtccag
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IGLV2-23*02

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aatcgcttctctggctccaagtctggcaacacggcctccctgacaatctctgggtccag
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IGLV3-25*d03

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ggtacttatcc

IGLV3-25*01

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ggtacttatcc

IGLV3-27*01

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IGLV1-36*01|Homo sapiens

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IGLV5-37*01|Homo sapiens

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tgcttct

|GLV5-39*01|Homo sapiens

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catttct

|GLV1-40*01|Homo sapiens

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>|GLV7-43*01|Homo sapiens

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gcccgggtctcaggctccctcctgggggcaaagctgccctgacactgtcaggtgtgcagc
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>|GLV1-44*01|Homo sapiens

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|GLV5-45*03|Homo sapiens

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cgcttct

>||GLV7-46*01||Homo sapiens

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>||GLV1-47*01||Homo sapiens

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aacttcgtgaacc

>||GLV1-51*01

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>||GLV5-52*01

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aagactca

>||GLV10-54*02

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agattctctgcatccaggtcaggaaacacagcctccctgaccattactggactccagcct
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>||GLV6-57*01

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cggttctctggctccatcgacagctcctccaactctgcctccctcaccatctctggactg
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>||GLV4-60*d03

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ctca

>other||GLV4-60*03

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cc

CLAIMS

1. A non-human vertebrate cell whose genome comprises the VH, D and JH gene segments from Table 3 upstream of a constant region at a heavy chain locus and the V κ and J κ gene segments from Table 10 or 11 upstream of a constant region at a light chain locus, in which
5 the gene segments in each locus are operably linked to the constant region thereof so that the cell is capable of producing an antibody heavy chain and an antibody light chain, or where the cell can develop into a vertebrate that expresses an antibody heavy chain and an antibody light chain, and in which the non-human vertebrate cell is a mouse or rat cell.
2. A non-human vertebrate whose genome comprises the VH, D and JH gene segments
10 from Table 3 upstream of a constant region at a heavy chain locus and the V κ and J κ gene segments from Table 10 or 11 upstream of a constant region at a light chain locus, in which the gene segments in each locus are operably linked to the constant region thereof so that the vertebrate is capable of producing an antibody heavy chain and an antibody light chain, and in which the non-human vertebrate is a mouse or rat.
- 15 3. A method of producing an antibody or an antigen binding fragment thereof, the method comprising immunising a vertebrate according to Claim 2 with an antigen and recovering the antibody or fragment or recovering a cell producing the antibody or fragment; optionally modifying the produced antibody or fragment so that it comprises human constant regions, in which the variable domains of the antibody are encoded by a human JH gene segment, a
20 human D gene segment and a human VH gene segment selected from the group consisting of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01, VH3-20*d01 and VH3-9*01 and a human J κ gene segment and a human V κ gene segment selected from the group consisting of V κ 4-1*01, V κ 2-28*01, V κ 1D-13*d01, V κ 1-12*01, V κ 1D-12*02, V κ 3-20*01, V κ 1-17*01, V κ 1D-39*01, V κ 3-11*01, V κ 1D-16*01 and V κ 1-9*d01.
- 25 4. A method according to Claim 3, in which the antigen is a multi-subunit human protein antigen.
5. A method of producing an antibody or an antigen binding fragment thereof, the method comprising (i) isolating an antibody or antigen binding fragment thereof from a cell according to Claim 1 or (ii) immunising a vertebrate according to Claim 2 with an antigen and
30 recovering the antibody or fragment, and optionally modifying the isolated antibody or fragment so that it comprises human constant regions.

6. A method according to Claim 5 further comprising
 - (a) isolating from the vertebrate according to Claim 2 a B-cell encoding an antibody that binds the antigen,
 - (b) identifying or copying a nucleotide sequence of the B-cell that encodes a VH domain of the antibody and/or identifying or copying nucleotide sequence of the B-cell that encodes a VL domain of the antibody; and
 - (c) using the sequence(s) to produce an isolated antibody or fragment comprising the VH and/or VL domain; optionally in which the isolated antibody or fragment comprises human constant regions.
7. A method according to any of Claims 3 to 6 further comprising formulating the antibody or fragment with a diluent, carrier, excipient or a drug to produce a pharmaceutical composition for human medical use, optionally further comprising packaging the composition in a sterile container, for example, a vial, tube, IV bag or syringe, further optionally producing a kit comprising combining the package with a label or instructions indicating use of the antibody composition for human medical use; optionally in which the label or instructions comprises a medicament batch number and/or a marketing authorisation number, further optionally an EMA or FDA marketing authorisation number.
8. A method according to any of Claims 3 to 7, in which the vertebrate is according to Claim 2 and the antibody or fragment produced by the method comprises
 - (a) a human heavy chain variable domain that is a recombinant of VH3-23*04, VH7-4-1*01, VH4-4*02, VH1-3*01, VH3-13*01, VH3-7*01, VH3-20*d01 or VH3-9*01, a human JH gene segment and a human D gene segment; and
 - (b) a human light chain variable domain that is a recombinant of Vκ4-1*01, Vκ2-28*01, Vκ1D-13*d01, Vκ1-12*01, Vκ1D-12*02, Vκ3-20*01, Vκ1-17*01, Vκ1D-39*01, Vκ3-11*01, Vκ1D-16*01 or Vκ1-9*d01 and a human Jκ gene segment; in which
 - (1) the JH gene segment is JH2*01, JH6*02, JH6*01 or JH3*02,
 - (2) the Jκ gene segment is Jκ4*01 or Jκ2*01,
 - (3) the JH gene segment is JH2*01, JH6*02, JH6*01 or JH3*02 and the Jκ gene segment is Jκ4*01 or Jκ2*01,

- 5
- (4) the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-23*04 and JH2*01 and a human light chain variable domain recombinant of V κ 4-1*01 and J κ 2*01 or
 - (5) the antibody or fragment produced by the method comprises a human heavy chain variable domain recombinant of VH3-7*01 and JH6*02 and a human light chain variable domain recombinant of V κ 2-28*01 and J κ 4*01.