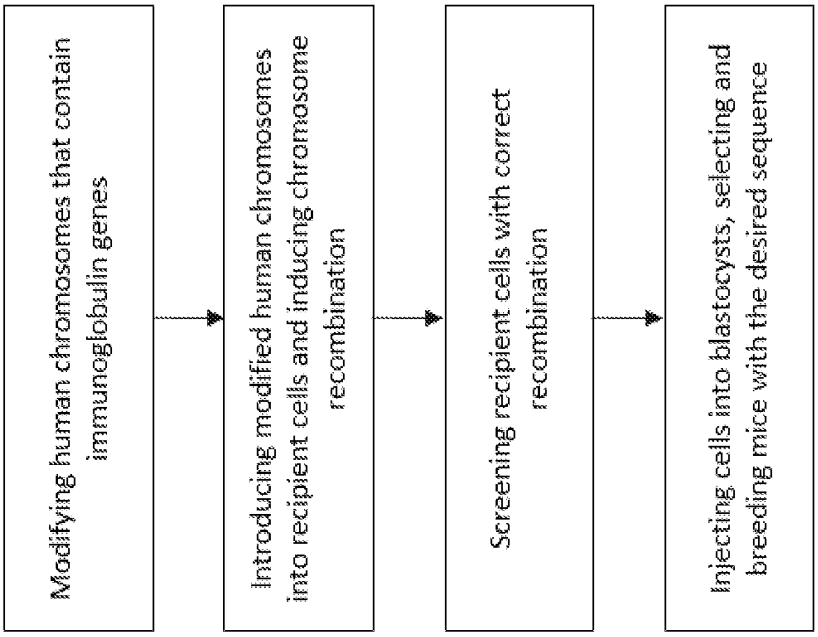

Modifying human chromosomes that contain immunoglobulin genes
Introducing modified human chromosomes into recipient cells and inducing chromosome recombination
Screening recipient cells with correct recombination
Injecting cells into blastocysts, selecting and breeding mice with the desired sequence

FIG. 1A

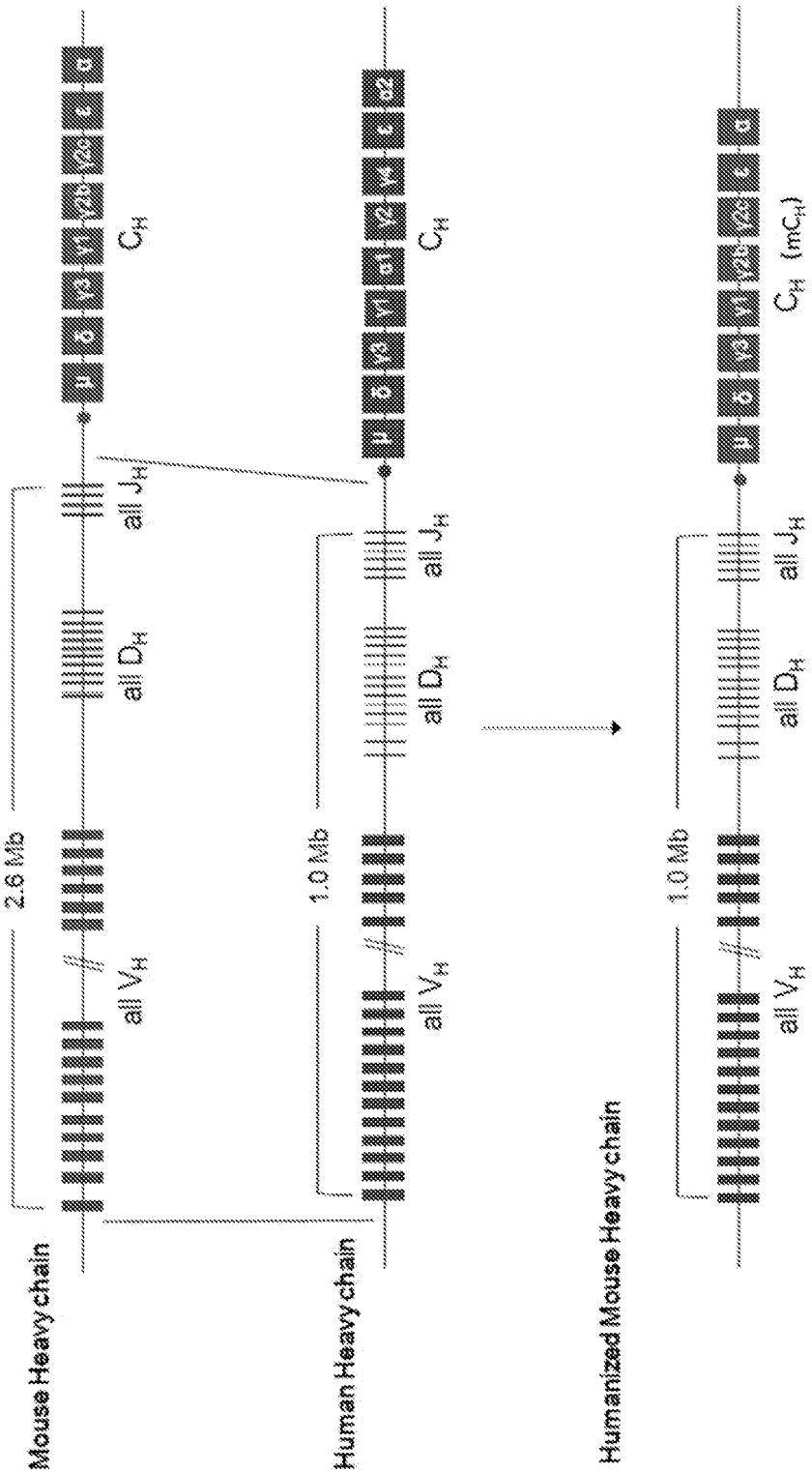

Mouse Heavy chain
2.6 Mb
all V_H
all D_H
all J_H
C_H
Human Heavy chain
1.0 Mb
all V_H
all D_H
all J_H
C_H
Humanized Mouse Heavy chain
1.0 Mb
all V_H
all D_H
all J_H
C_H (mC_H)

FIG. 1B

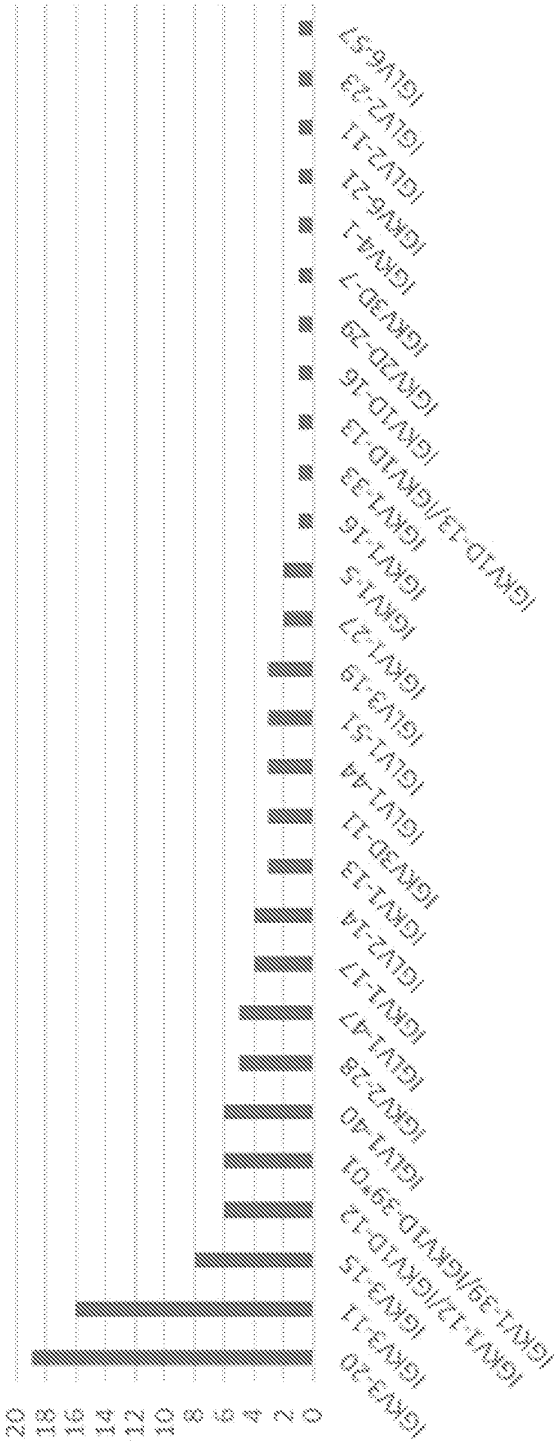

V region
20
18
16
14
12
10
8
6
4
2
0
IGHV3-30
IGHV3-11
IGHV3-15
IGHV1-12/IGHV1D-12
IGHV1-39/IGHV1D-39*01
IGHV4-40
IGHV2-26
IGHV1-47
IGHV1-17
IGHV2-24
IGHV1-13
IGHV3D-11
IGLV1-44
IGLV1-51
IGHV3-19
IGHV1-21
IGHV1-15
IGHV1-16
IGHV1-33
IGHV1D-13/IGHV1D-22
IGHV1D-12
IGHV1D-16
IGHV2D-26
IGHV3D-7
IGHV4-1
IGHV6-21
IGLV2-11
IGLV2-23
IGLV6-57

FIG. 2A

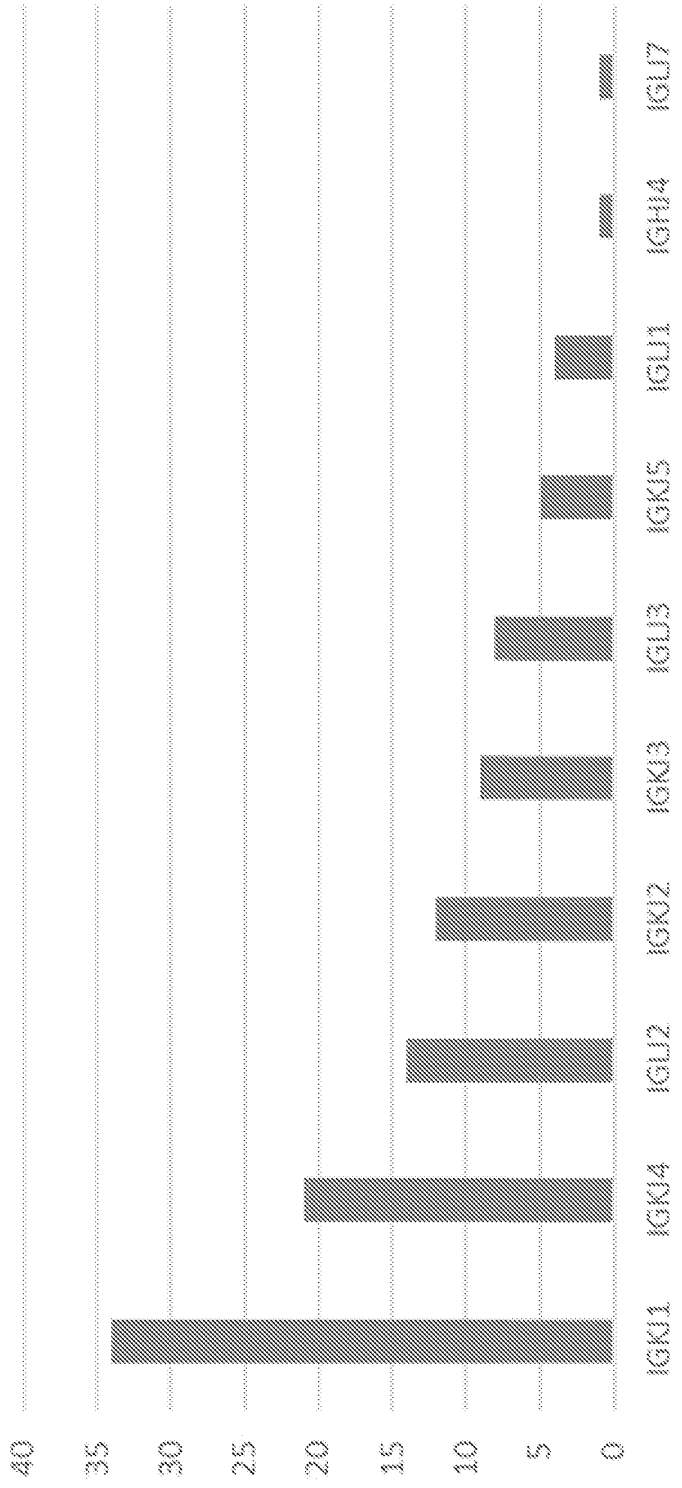

J region
40
35
30
25
20
15
10
5
0
IGKJ1
IGKJ4
IGLJ2
IGKJ2
IGKJ3
IGLJ3
IGKJ5
IGLJ1
IGHJ4
IGLJ7

FIG. 2B

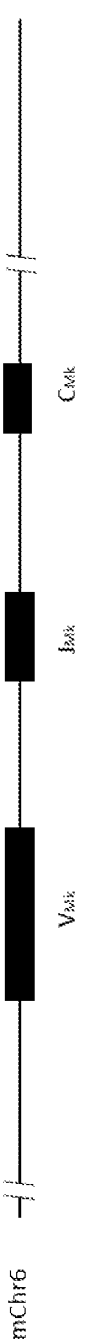

mChr6
VκK
JκK
CκK

FIG. 3A

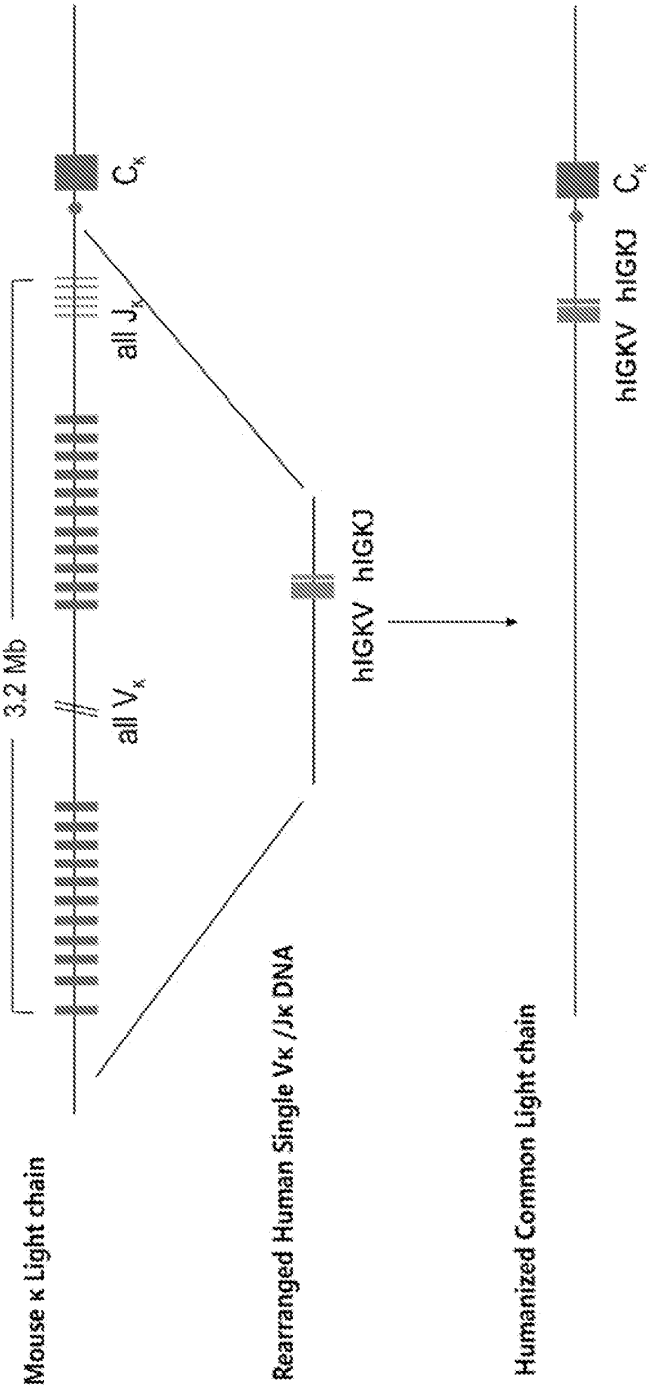

3.2 Mb
all Vκ
all Jκ
Cκ
Mouse κ Light chain
hIGKV hIGKJ
Rearranged Human Single Vκ /Jκ DNA
hIGKV hIGKJ
Cκ
Humanized Common Light chain

FIG. 3B

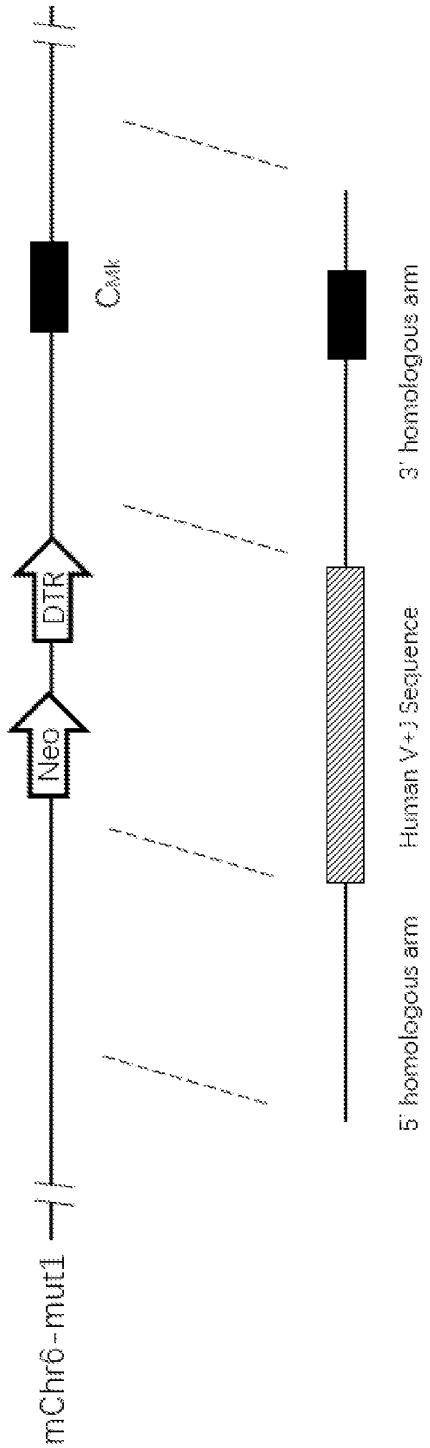
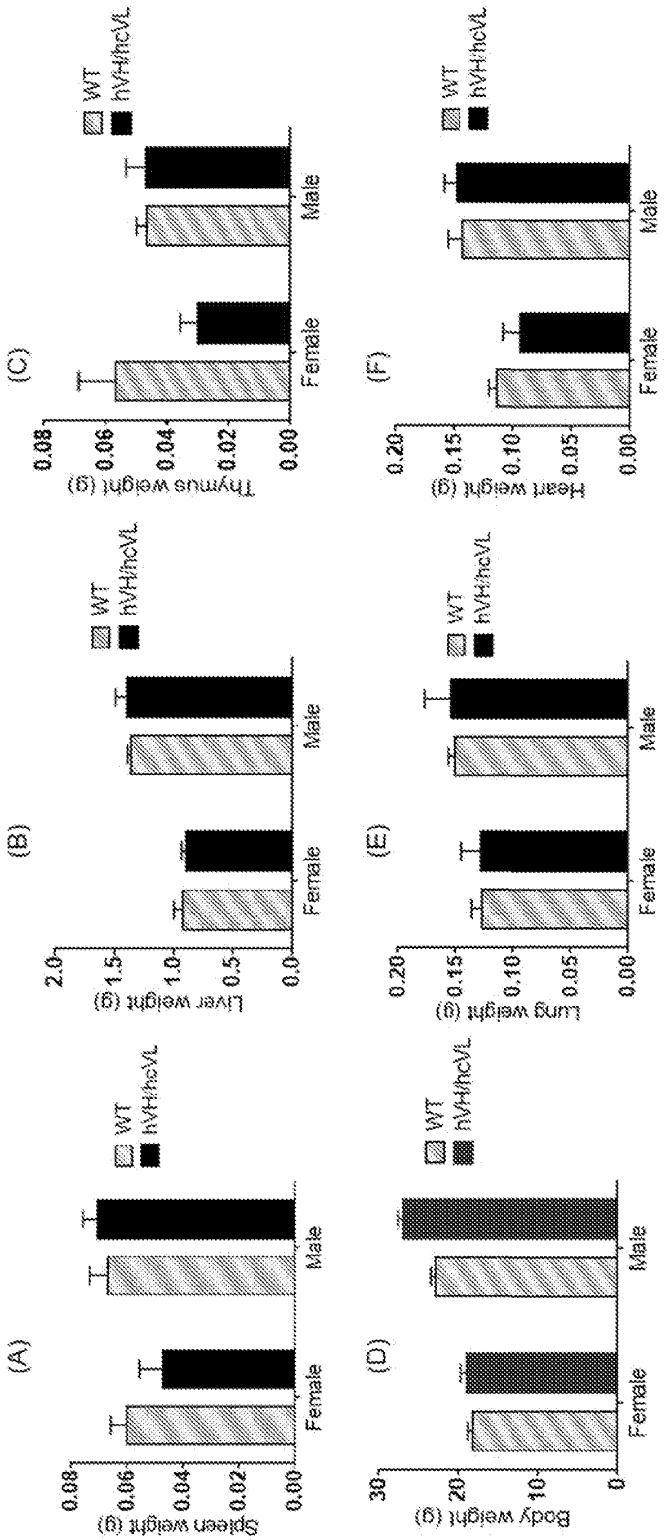

mChr6-mut1
Neo
DTR
Cmk
5' homologous arm
Human V+J Sequence
3' homologous arm

FIG. 4


(A)
Spleen weight (g)
0.08
0.06
0.04
0.02
0.00
Female
Male
WT
hVH/hcVL
(B)
Liver weight (g)
2.0
1.5
1.0
0.5
0.0
Female
Male
WT
hVH/hcVL
(C)
Thymus weight (g)
0.08
0.06
0.04
0.02
0.00
Female
Male
WT
hVH/hcVL
(D)
Body weight (g)
30
20
10
0
Female
Male
WT
hVH/hcVL
(E)
Lung weight (g)
0.20
0.15
0.10
0.05
0.00
Female
Male
WT
hVH/hcVL
(F)
Heart weight (g)
0.20
0.15
0.10
0.05
0.00
Female
Male
WT
hVH/hcVL

FIGS. 5A-5F

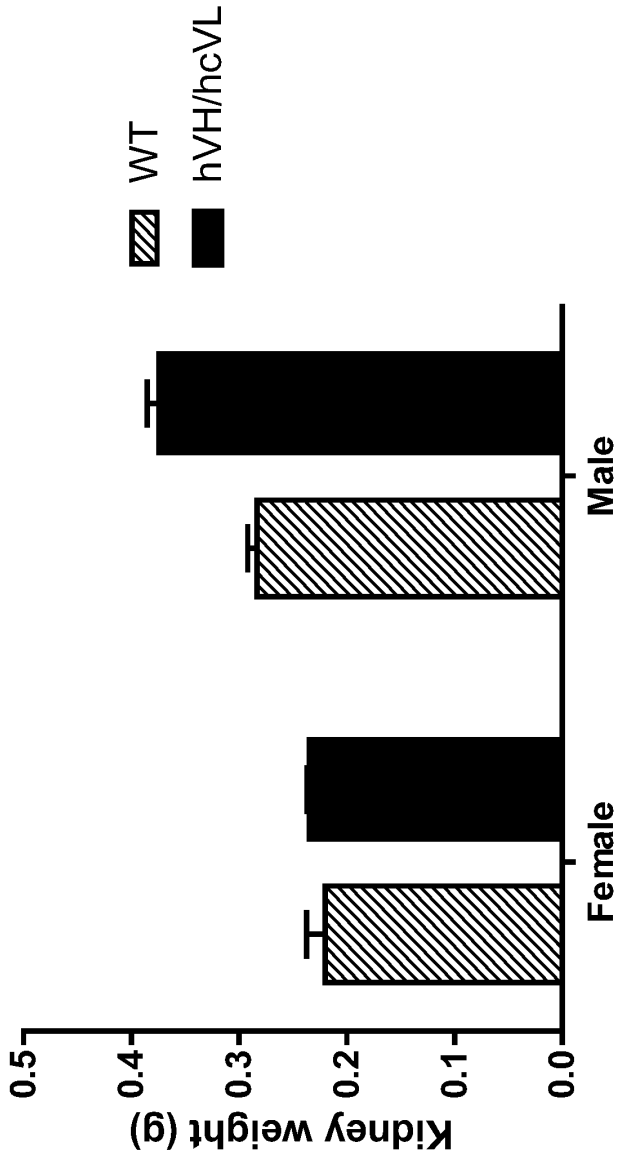


FIG. 5G

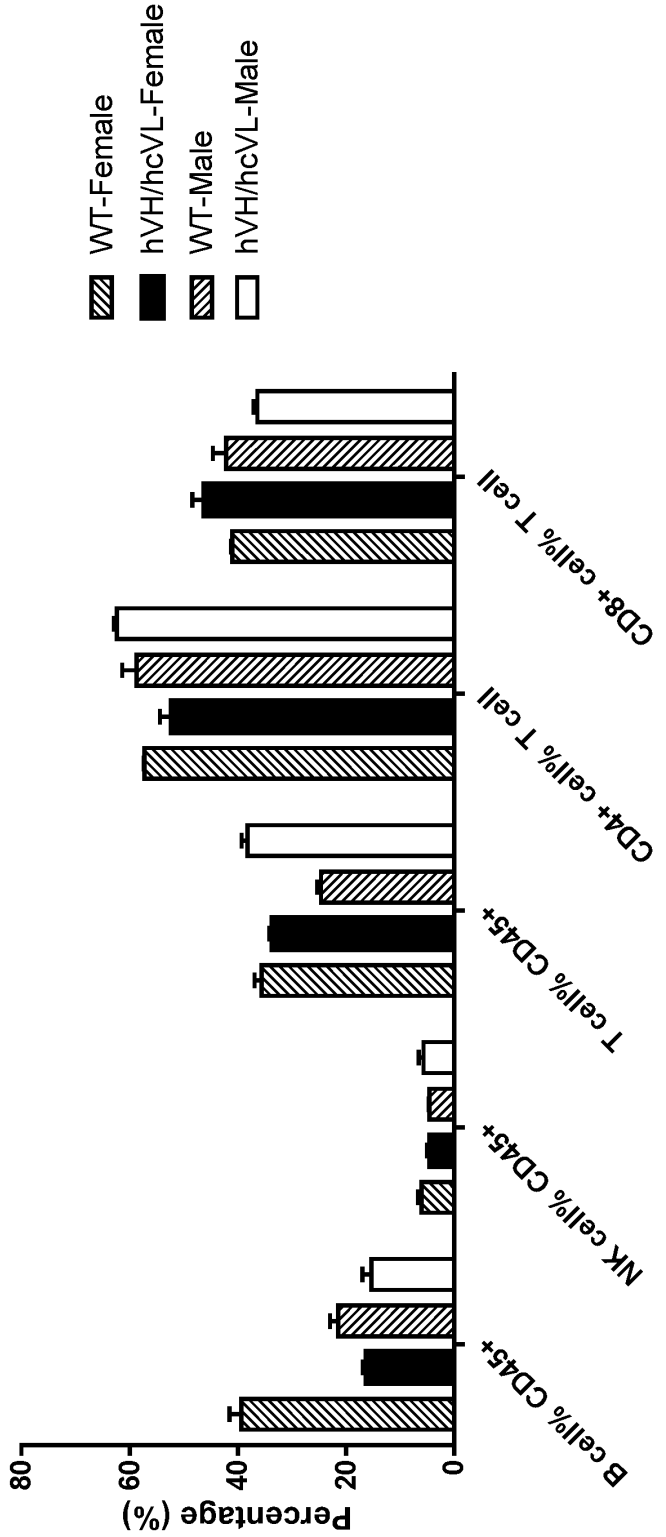

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage (%)
0
20
40
60
80
B cell% CD45+
NK cell% CD45+
T cell% CD45+
CD4+ cell% T cell
CD8+ cell% T cell

FIG. 6A

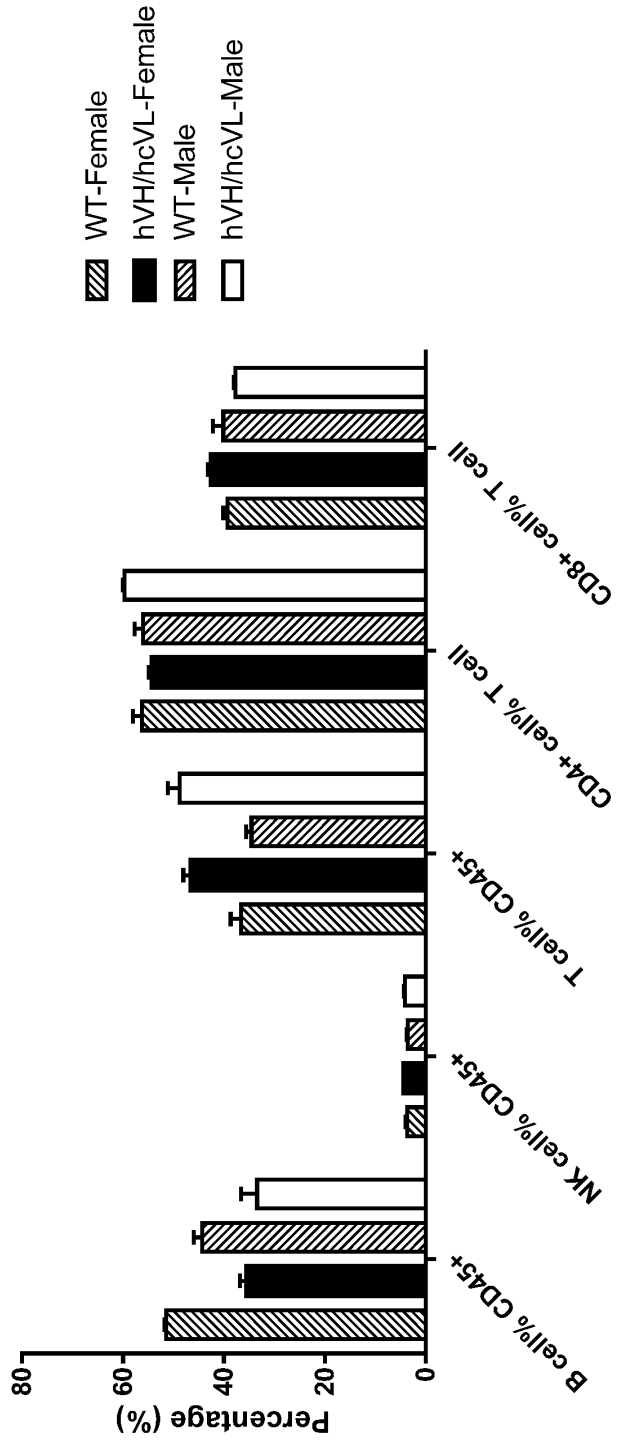

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage (%)
0
20
40
60
80
B cell% CD45+
NK cell% CD45+
T cell% CD45+
CD4+ cell% T cell
CD8+ cell% T cell

FIG. 6B

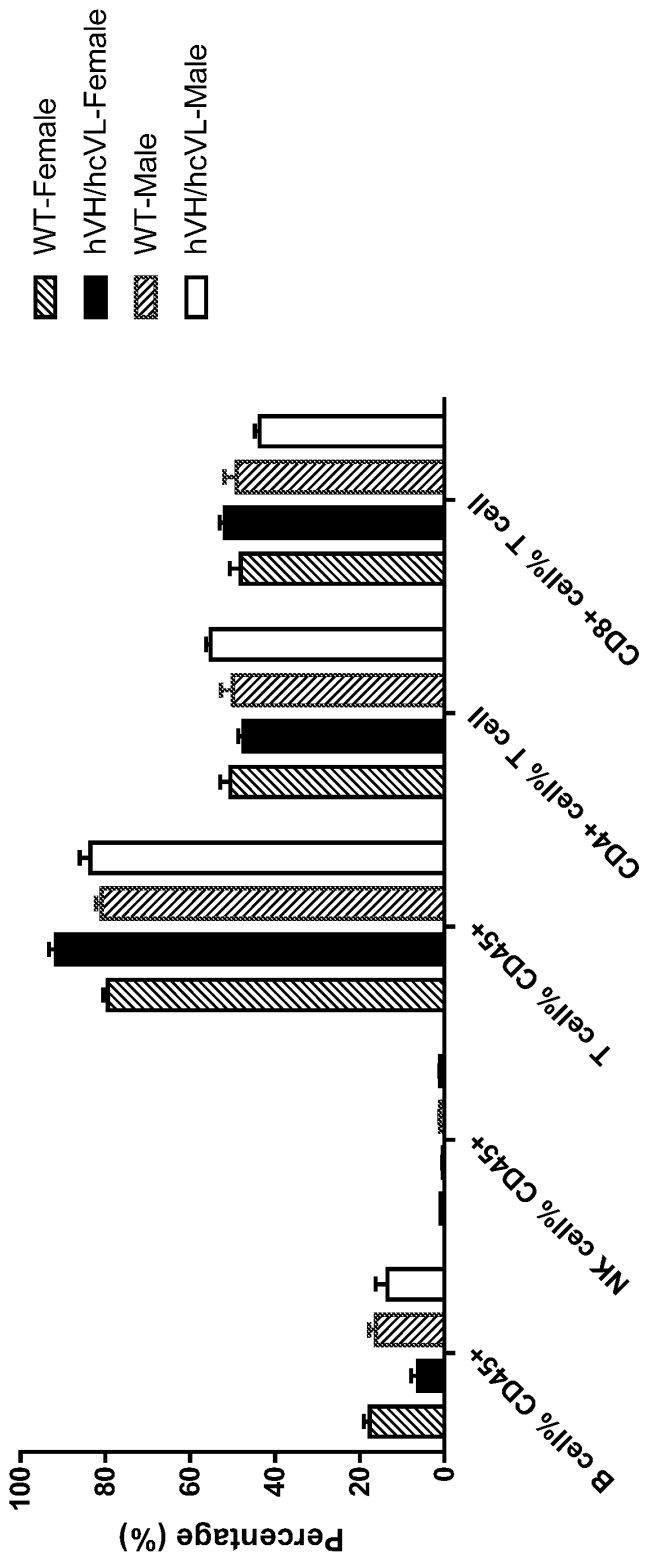

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage (%)
100
80
60
40
20
0
B cell% CD45+
NK cell% CD45+
T cell% CD45+
CD4+ cell% T cell
CD8+ cell% T cell

FIG. 7

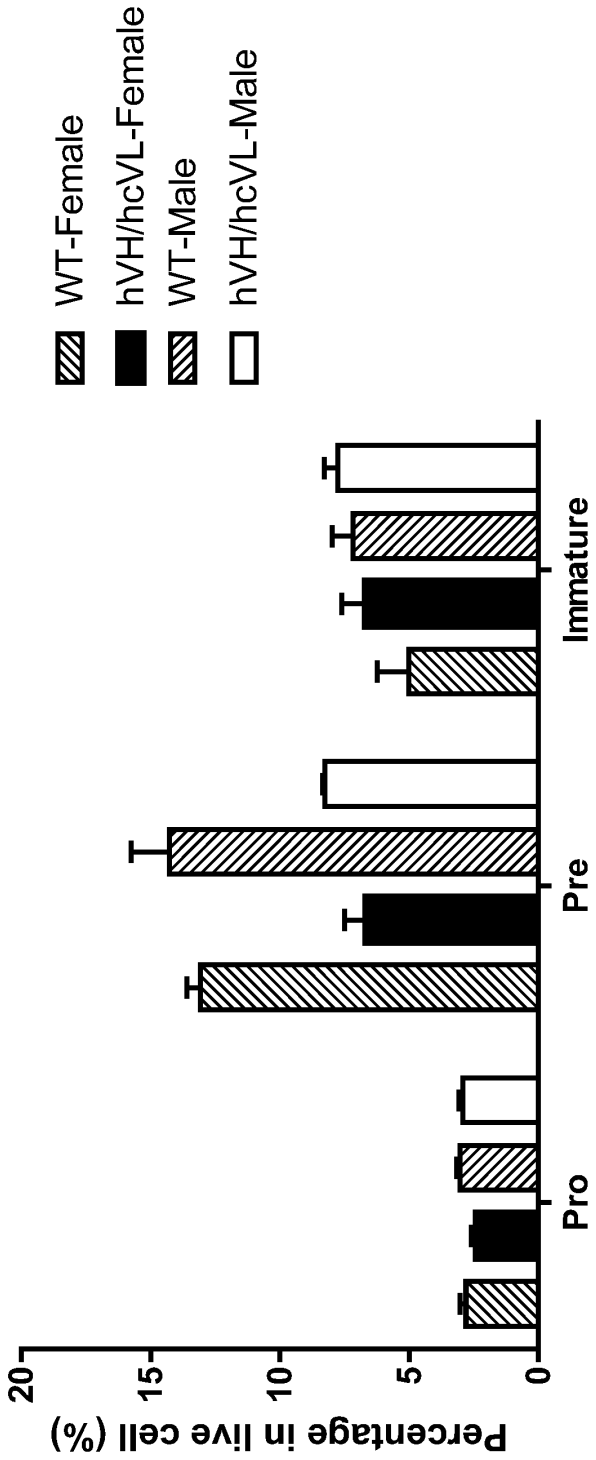

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
0
5
10
15
20
Pro
Pre
Immature

FIG. 8A

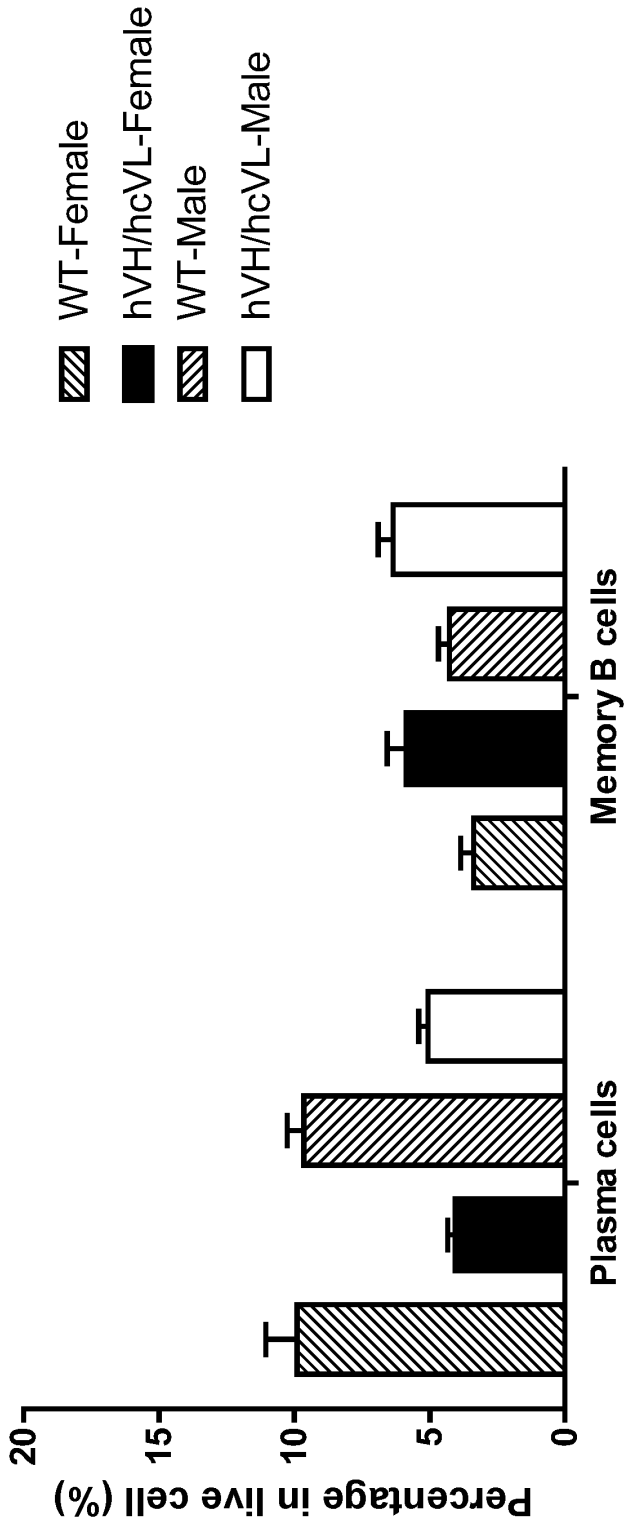

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
0
5
10
15
20
Plasma cells
Memory B cells

FIG. 8B

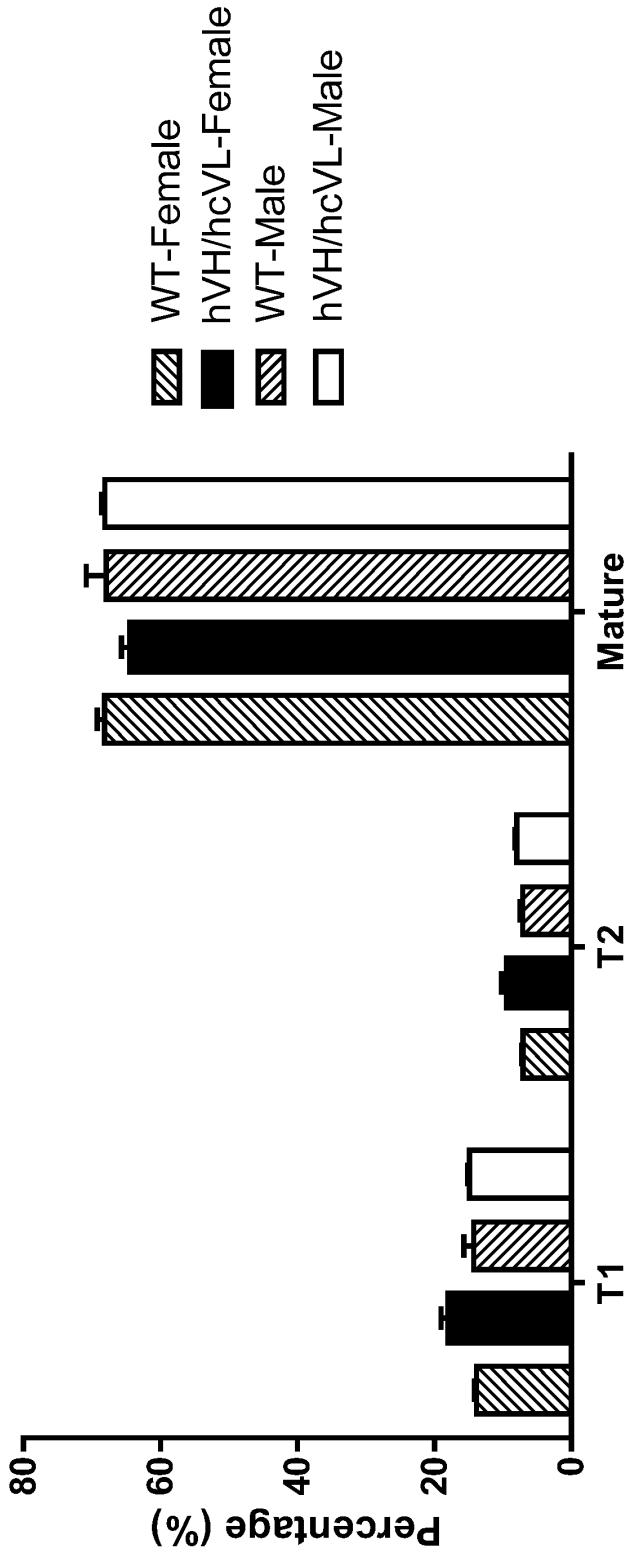
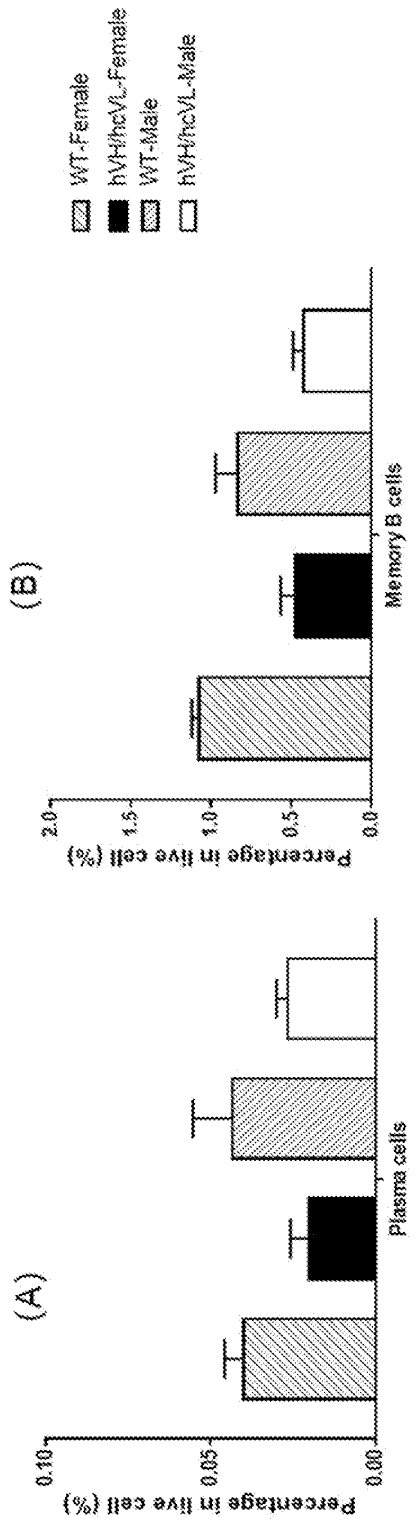

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage (%)
0
20
40
60
80
T1
T2
Mature

FIG. 9


WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
(A)
Percentage in live cell (%)
0.10
0.05
0.00
Plasma cells
(B)
Percentage in live cell (%)
2.0
1.5
1.0
0.5
0.0
Memory B cells

FIGS. 10A-10B

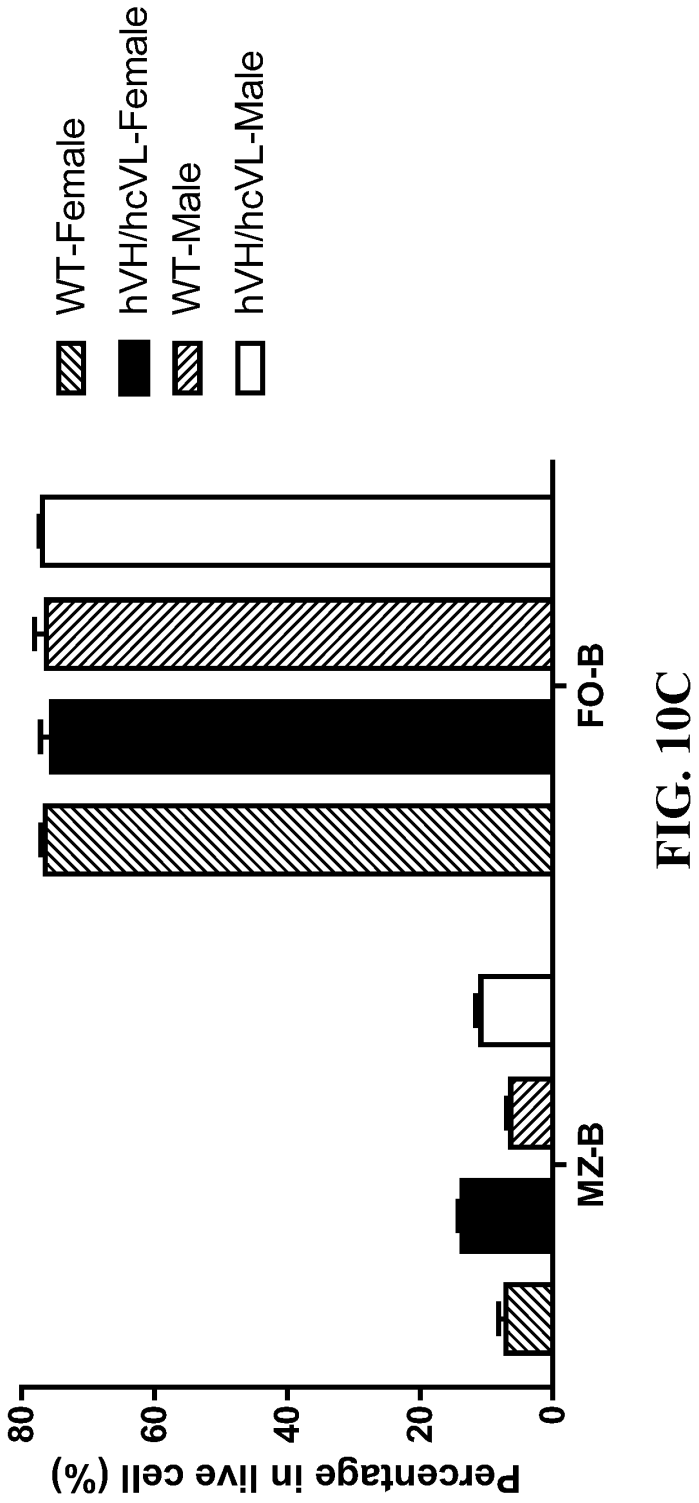
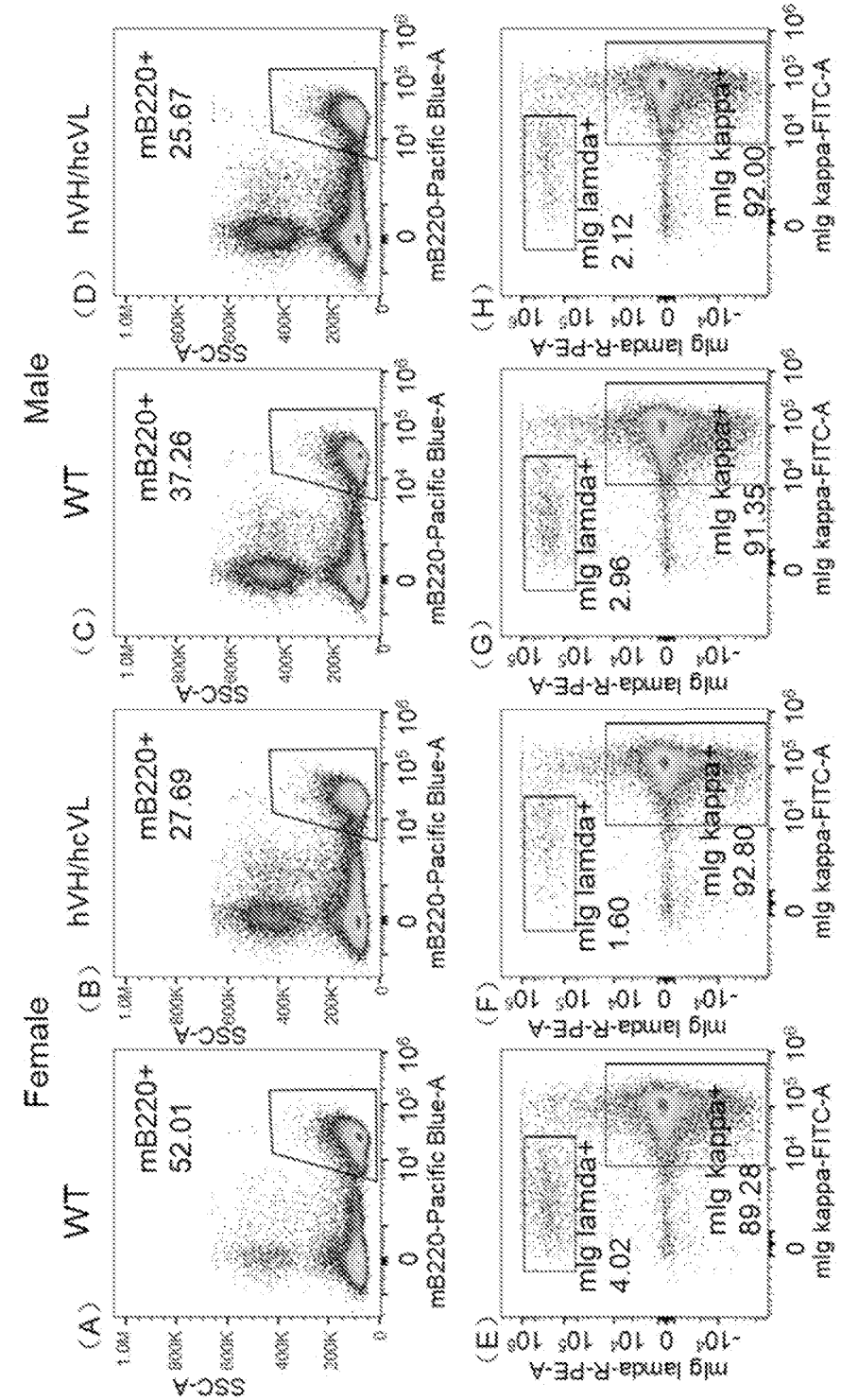

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
0
20
40
60
80
MZ-B
FO-B

FIG. 10C


Female
Male
(A) WT
(B) hVH/hcVL
(C) WT
(D) hVH/hcVL
(E)
(F)
(G)
(H)
mB220+
52.01
mB220+
27.69
mB220+
37.26
mB220+
25.67
mIg lamda+
4.02
mIg kappa+
89.28
mIg lamda+
1.60
mIg kappa+
92.80
mIg lamda+
2.96
mIg kappa+
91.35
mIg lamda+
2.12
mIg kappa+
92.00
SSC-A
mB220-Pacific Blue-A
mIg lamda-R-PE-A
mIg kappa-FITC-A

FIGS. 11A-11H

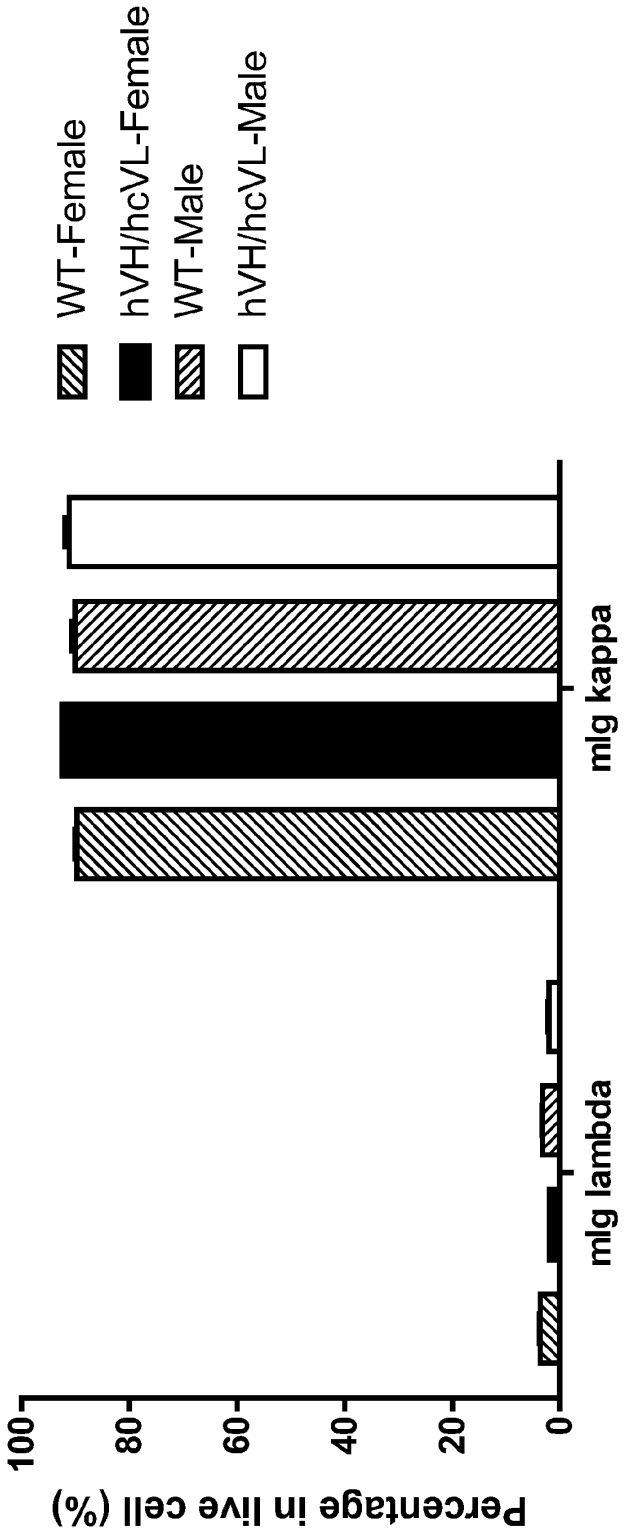

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
100
80
60
40
20
0
mlg lambda
mlg kappa

FIG. 11I

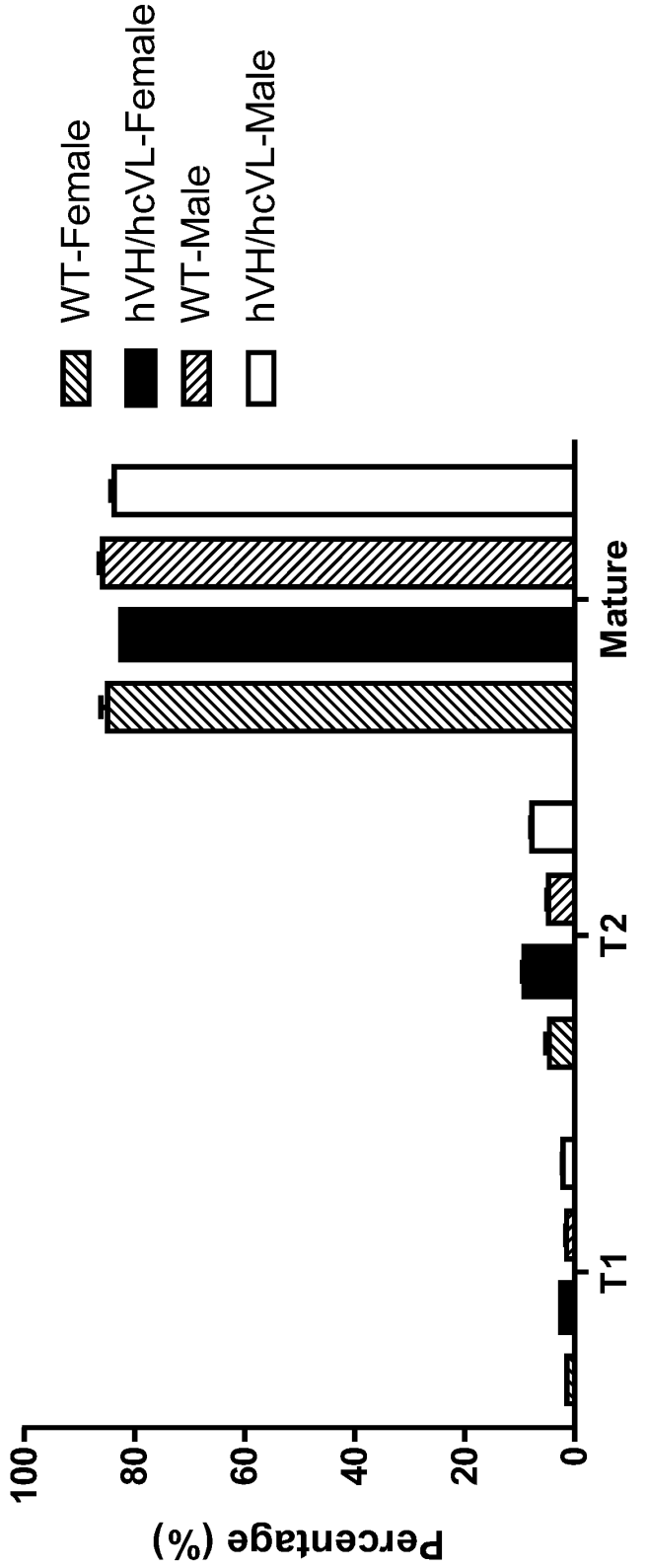

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage (%)
100
80
60
40
20
0
T1
T2
Mature

FIG. 12A

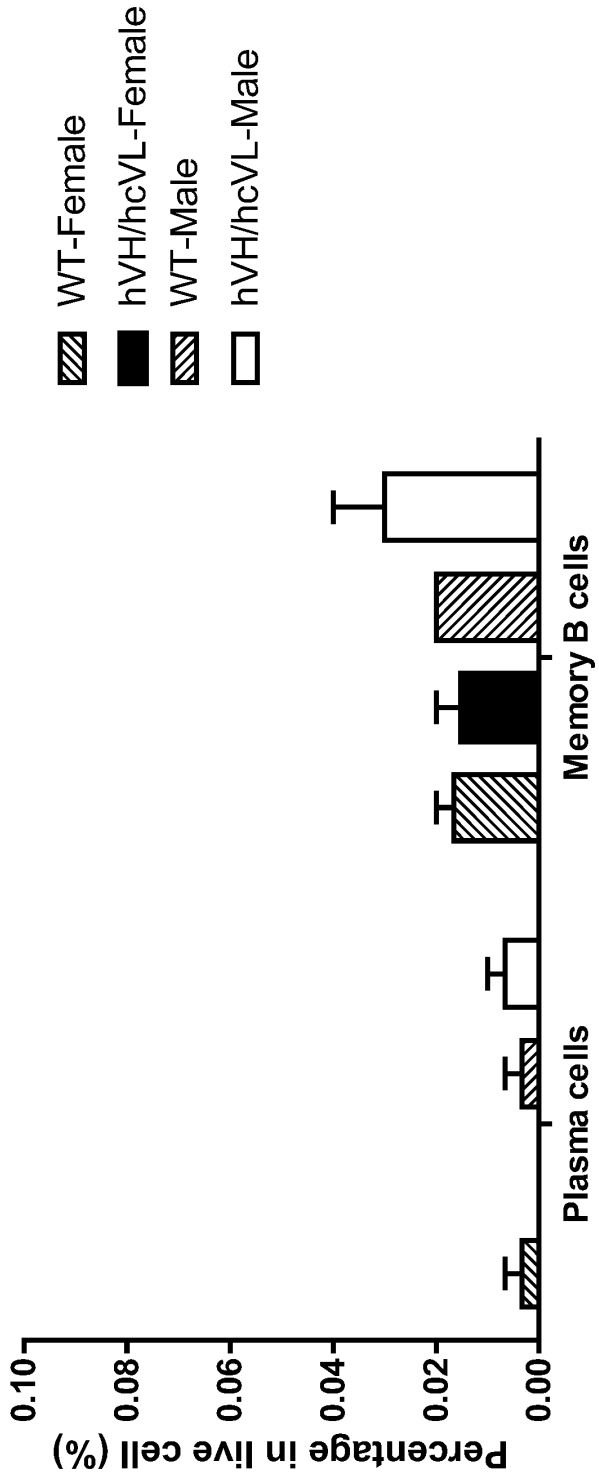
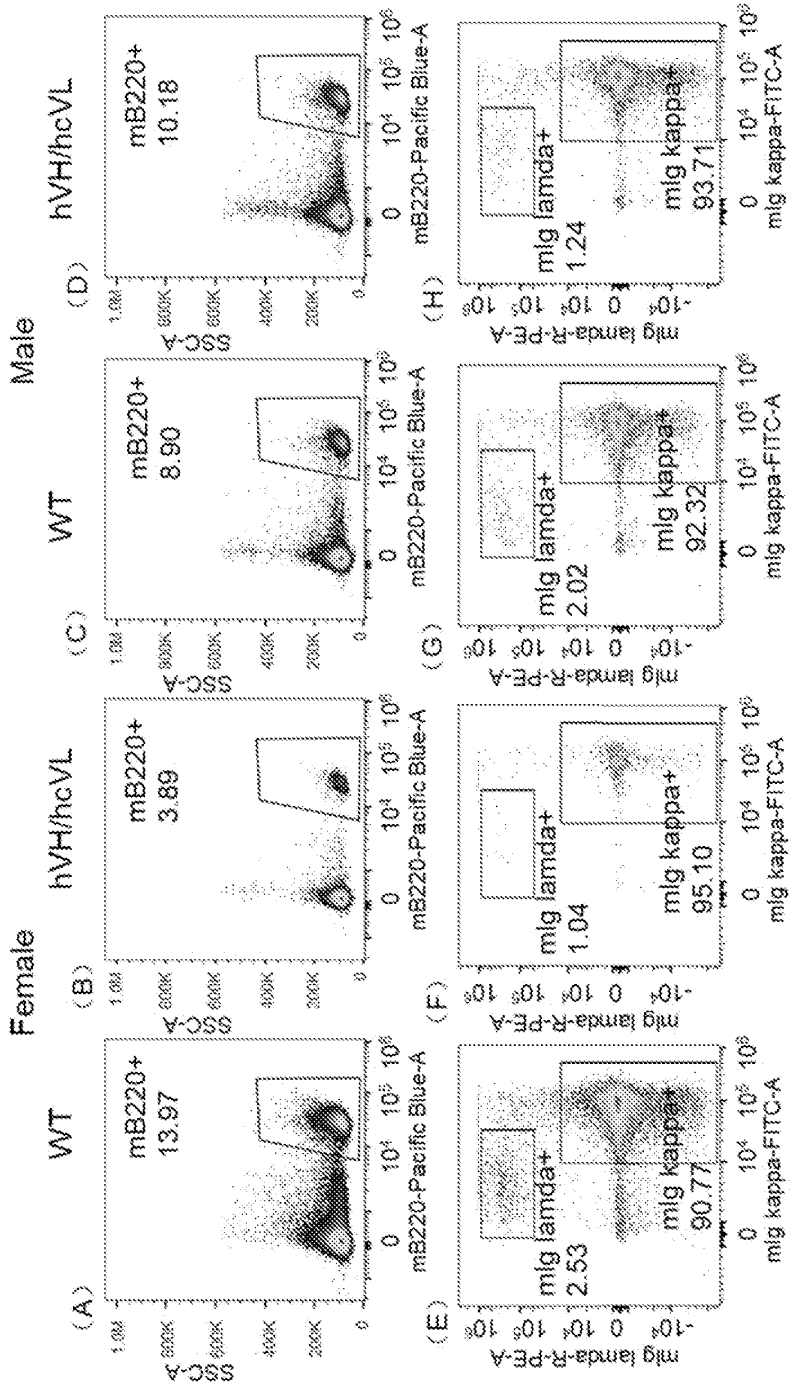

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
0.10
0.08
0.06
0.04
0.02
0.00
Plasma cells
Memory B cells

FIG. 12B


Female
Male
WT
hVH/hcVL
WT
hVH/hcVL
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)
mB220+
13.97
mB220+
3.89
mB220+
8.90
mB220+
10.18
mIg lamda+
2.53
mIg kappa+
90.77
mIg lamda+
1.04
mIg kappa+
95.10
mIg lamda+
2.02
mIg kappa+
92.32
mIg lamda+
1.24
mIg kappa+
93.71
SSC-A
mB220-Pacific Blue-A
mIg lamda-R-PE-A
mIg kappa-FITC-A

FIGS. 13A-13H

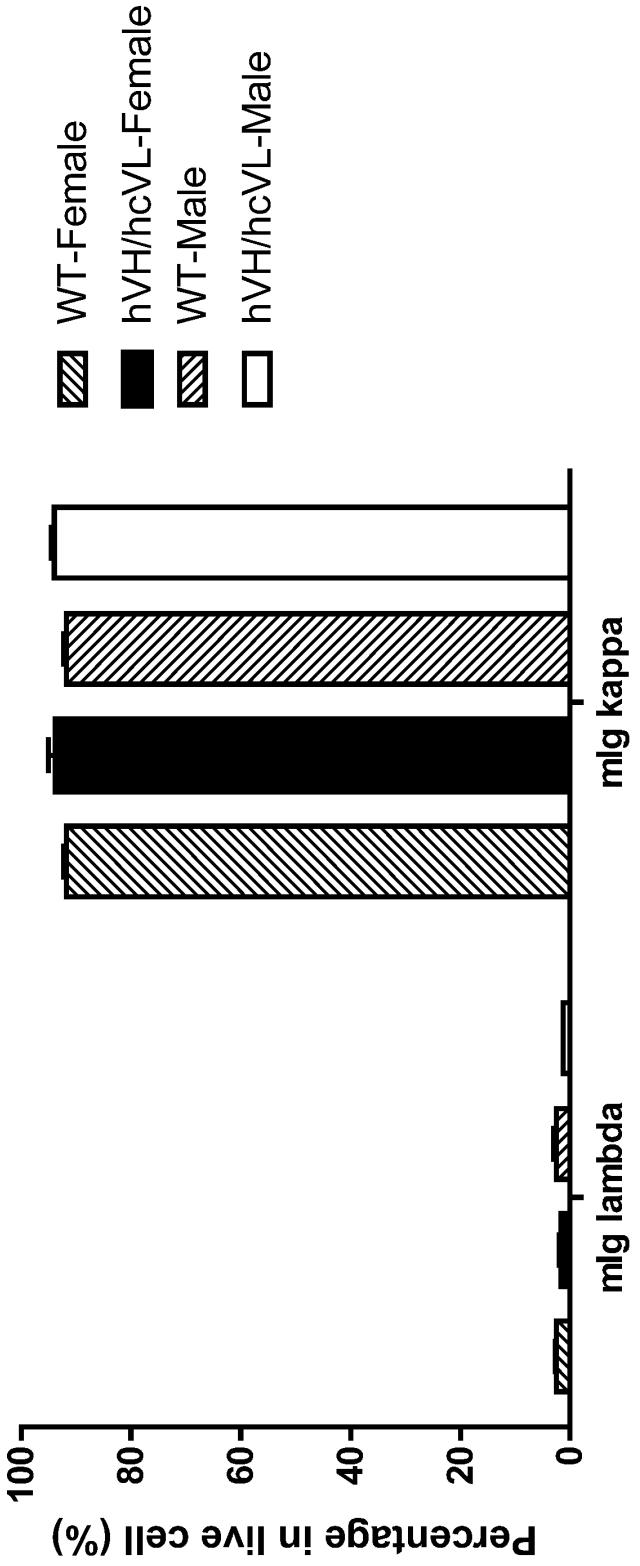

WT-Female
hVH/hcVL-Female
WT-Male
hVH/hcVL-Male
Percentage in live cell (%)
100
80
60
40
20
0
mlg lambda
mlg kappa

FIG. 13I

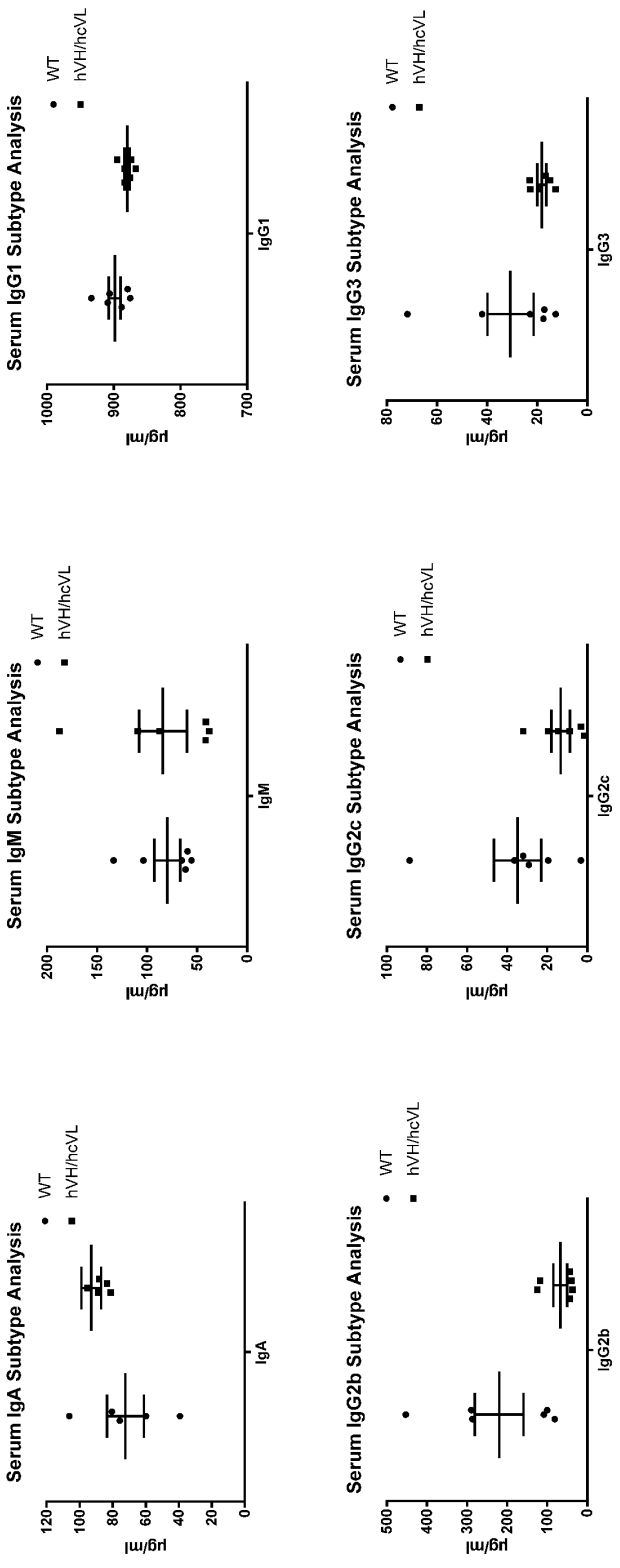

Serum IgA Subtype Analysis
WT
hVH/hcVL
μg/ml
120
100
80
60
40
20
0
IgA
Serum IgM Subtype Analysis
WT
hVH/hcVL
μg/ml
200
150
100
50
0
IgM
Serum IgG1 Subtype Analysis
WT
hVH/hcVL
μg/ml
1000
900
800
700
IgG1
Serum IgG2b Subtype Analysis
WT
hVH/hcVL
μg/ml
500
400
300
200
100
0
IgG2b
Serum IgG2c Subtype Analysis
WT
hVH/hcVL
μg/ml
100
80
60
40
20
0
IgG2c
Serum IgG3 Subtype Analysis
WT
hVH/hcVL
μg/ml
80
60
40
20
0
IgG3

FIG. 13J

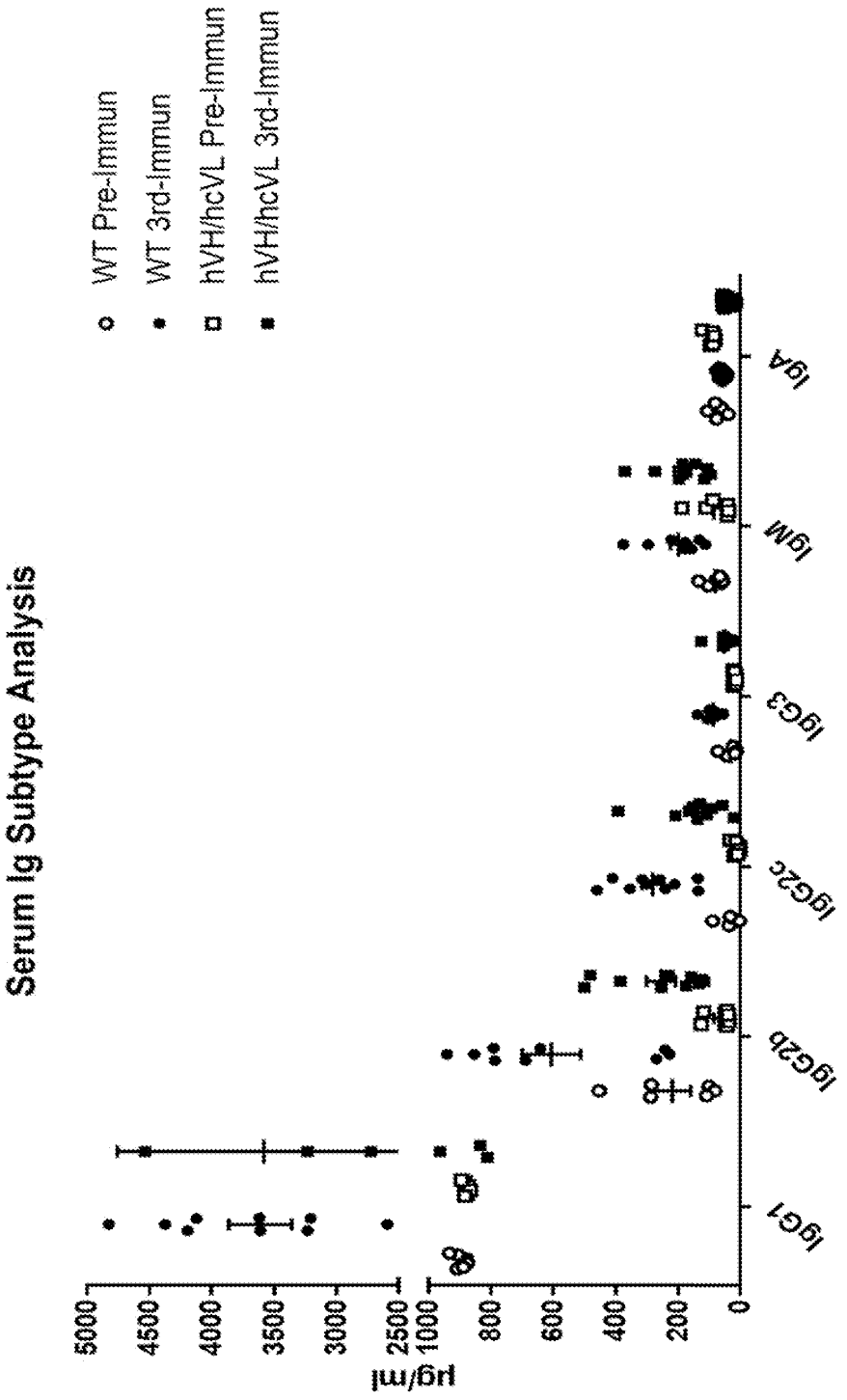

Serum Ig Subtype Analysis
WT Pre-Immun
WT 3rd-Immun
hVH/hcVL Pre-Immun
hVH/hcVL 3rd-Immun
μg/ml
5000
4500
4000
3500
3000
2500
1000
800
600
400
200
0
IgA
IgM
IgG3
IgG2c
IgG2b
IgG1

FIG. 13H

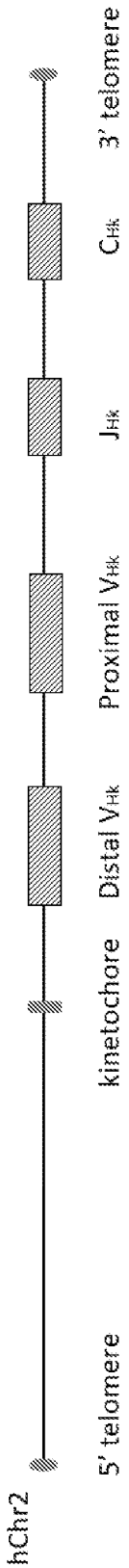

hChr2
5' telomere
kinetochore
Distal VHk
Proximal VHk
JHk
CHk
3' telomere

FIG. 14

Proximal V-CLUSTER from 3' (top of column) to 5' (bottom of column)	Distal V-CLUSTER from 3' (bottom of column) to 5' (top of column)
IGKV4-1	
IGKV5-2	
IGKV7-3	
IGKV2-4	
IGKV1-5	
IGKV1-6	
IGKV3-7	IGKV3D-7
IGKV1-8	IGKV1D-8
	IGKV1D-43
	IGKV1D-42
IGKV1-9	
IGKV2-10	IGKV2D-10
IGKV3-11	IGKV3D-11
IGKV1-12	IGKV1D-12
IGKV1-13	IGKV1D-13
IGKV2-14	IGKV2D-14
IGKV3-15	IGKV3D-15
IGKV1-16	IGKV1D-16
IGKV1-17	IGKV1D-17
	IGKV6D-41
IGKV2-18	IGKV2D-18
IGKV2-19	IGKV2D-19
IGKV3-20	IGKV3D-20
IGKV6-21	IGKV6D-21
IGKV1-22	IGKV1D-22
IGKV2-23	IGKV2D-23
IGKV2-24	IGKV2D-24
IGKV3-25	IGKV3D-25
IGKV2-26	IGKV2D-26
IGKV1-27	IGKV1D-27
IGKV2-28	IGKV2D-28
IGKV2-29	IGKV2D-29
IGKV2-30	IGKV2D-30
IGKV3-31	IGKV3D-31
IGKV1-32	IGKV1D-32
IGKV1-33	IGKV1D-33
IGKV3-34	IGKV3D-34
IGKV1-35	IGKV1D-35
IGKV2-36	IGKV2D-36
IGKV1-37	IGKV1D-37
IGKV2-38	IGKV2D-38
IGKV1-39	IGKV1D-39
IGKV2-40	IGKV2D-40

FIG. 15


Telomeric
5'
200 kb
400 kb
600 kb
800 kb
1 000 kb
Enhancer
4.5
~60
Centromeric
G3
G1
EP1
A1
Enhancer
GP
G2
G4
E
A2
Enhancer
3'
1 250 kb
26
19
13
25
~55
18
23
10
25

FIG. 16

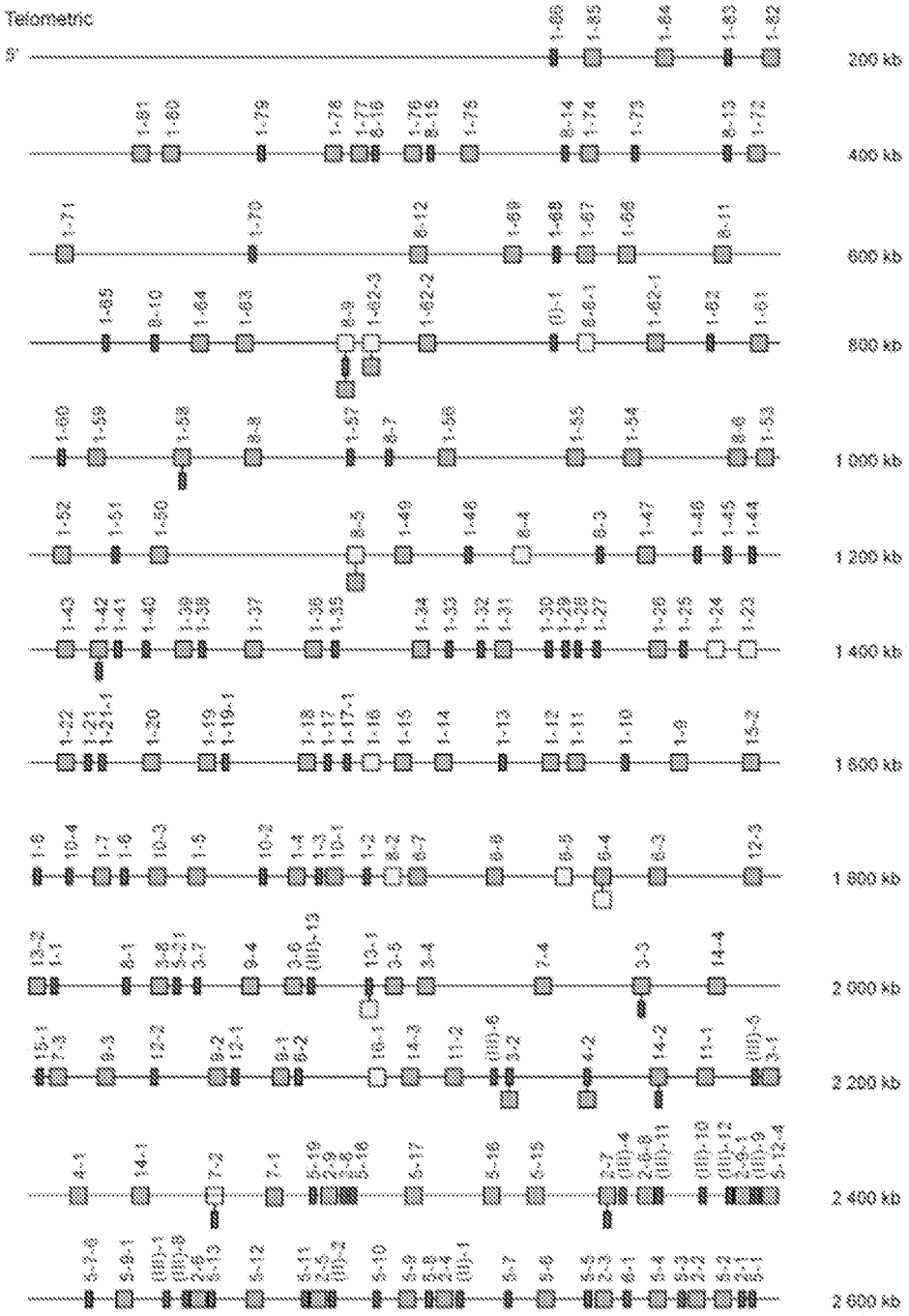

Telomeric
5'
200 kb
400 kb
600 kb
800 kb
1 000 kb
1 200 kb
1 400 kb
1 600 kb
1 800 kb
2 000 kb
2 200 kb
2 400 kb
2 600 kb

FIG. 17

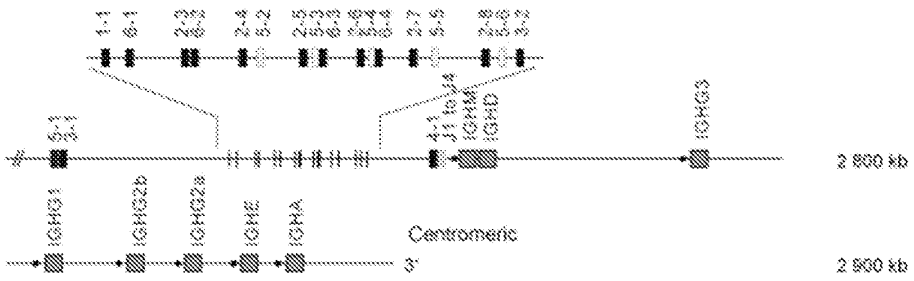


FIG. 17 (Continued)

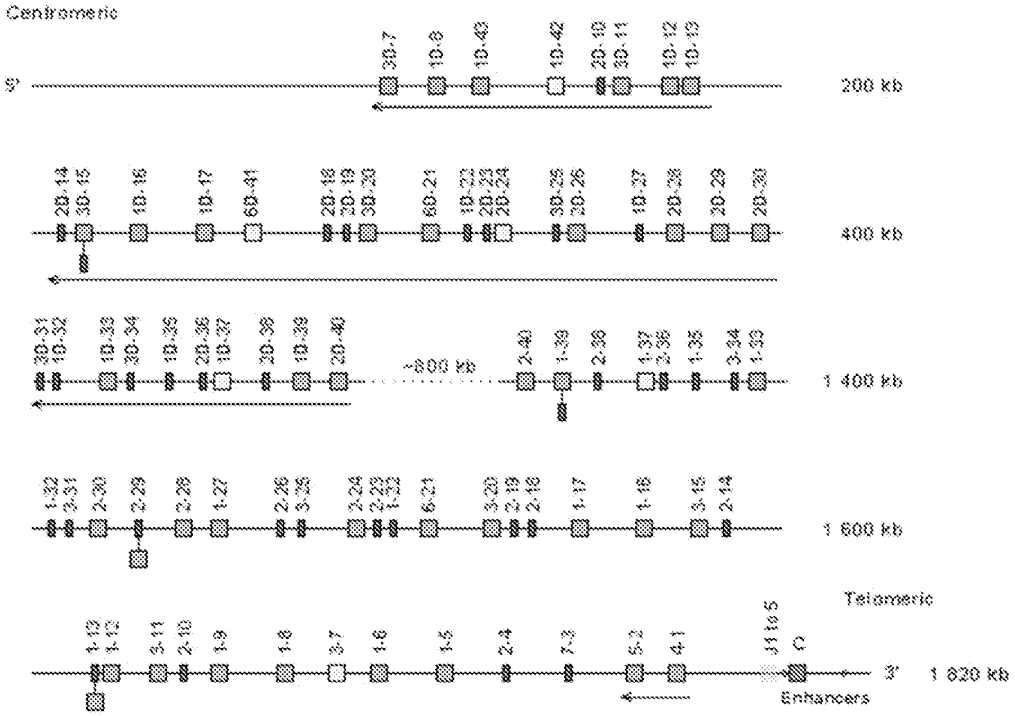


FIG. 18

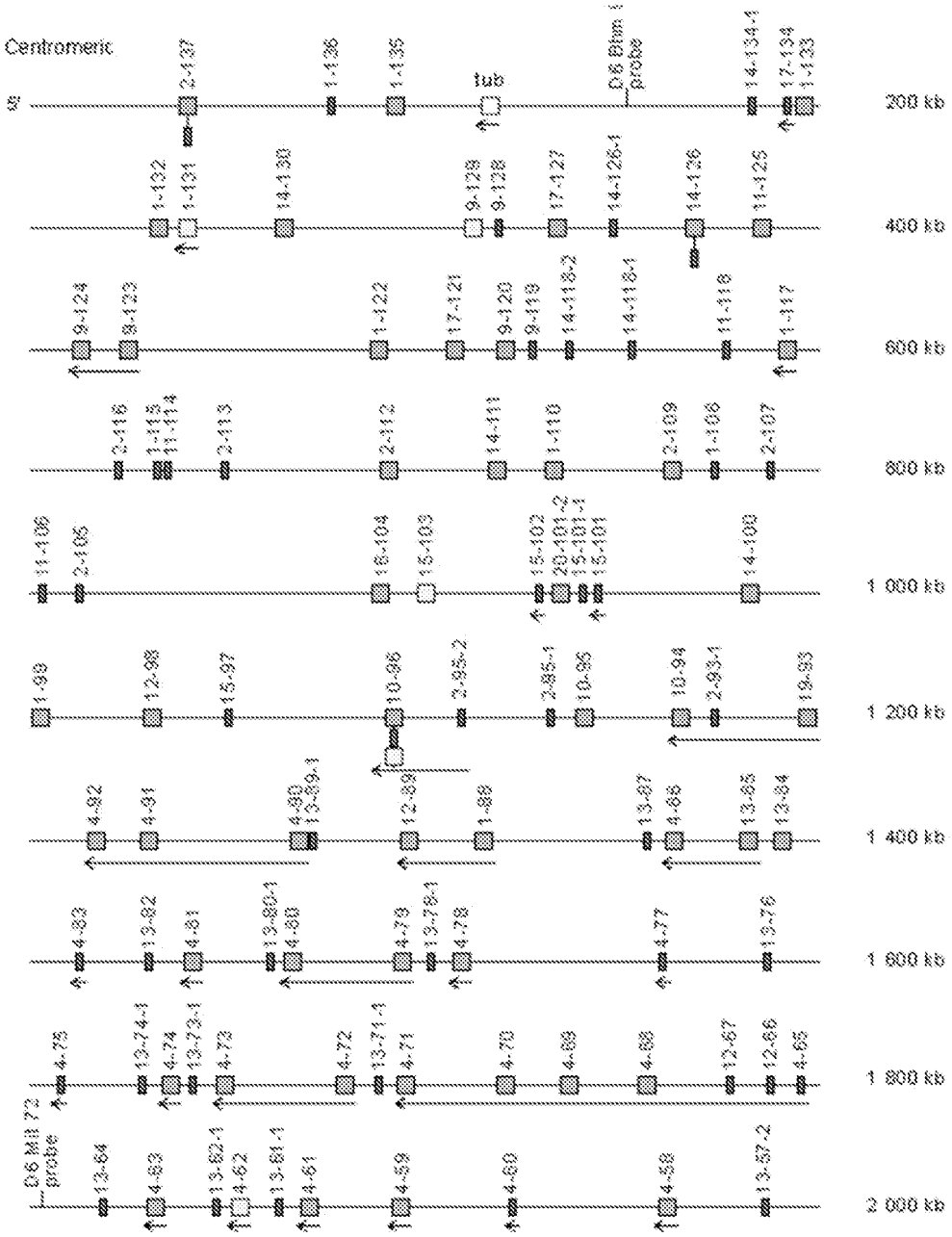

Centromeric
tub
0.6 Bbm I probe
0.6 Mlu I probe
200 kb
400 kb
600 kb
800 kb
1 000 kb
1 200 kb
1 400 kb
1 600 kb
1 800 kb
2 000 kb

FIG. 19

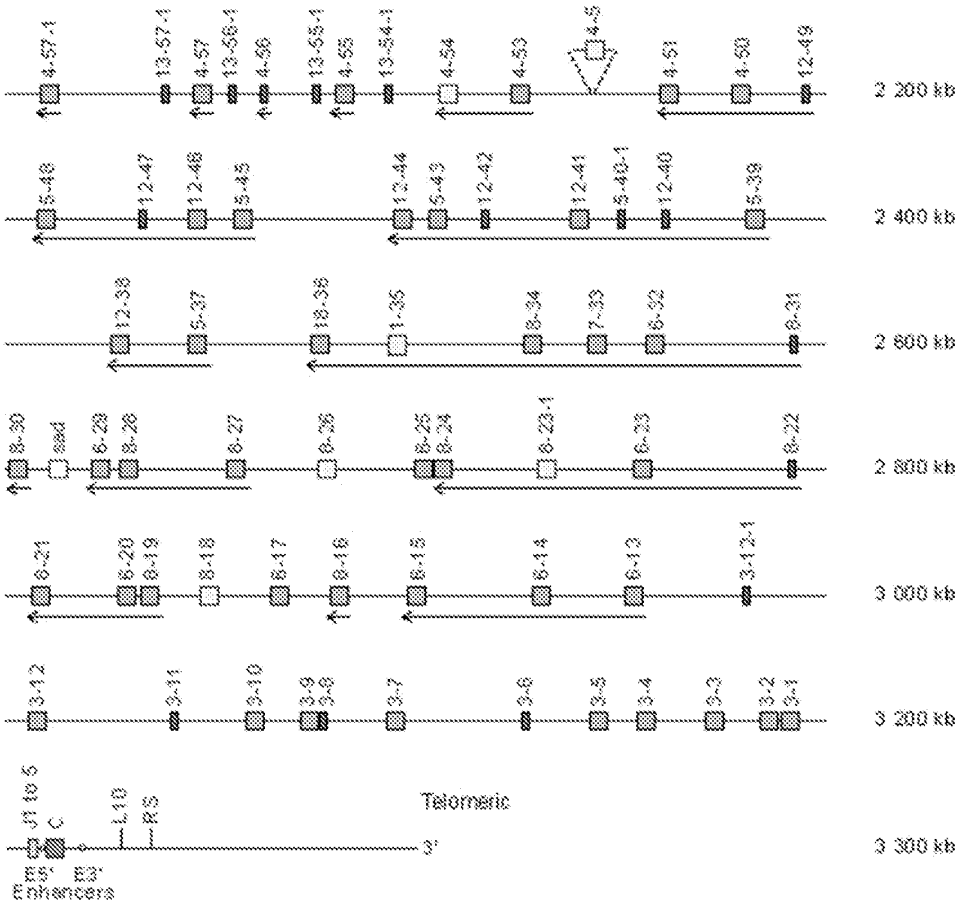


FIG. 19 (Continued)

FIG. 20

IMGT						NCBI		
Gene	Location	Orientation	Locus	Position	Accession number	Positions	Gene positions on chromosome	Accession number	Gene positions in sequences
IGHA2	14q32.33	REV	IGH		J00221	1227..1618	105124322..105124713	NT_026437.11	87054322..87054713
IGHA2	14q32.33	REV	IGH		J00221	684..1004	105124936..105125256	NT_026437.11	87054936..87055256
IGHA2	14q32.33	REV	IGH		J00221	164..469	105125474..105125776	NT_026437.11	87055474..87055776
IGHE	14q32.33	REV	IGH		J00222	2540..2868	105137451..105137779	NT_026437.11	87067451..87067779
IGHE	14q32.33	REV	IGH		J00222	2133..2456	105137863..105138186	NT_026437.11	87067863..87068186
IGHE	14q32.33	REV	IGH		J00222	1726..2046	105138273..105138593	NT_026437.11	87068273..87068593
IGHE	14q32.33	REV	IGH		J00222	1210..1518	105138801..105139109	NT_026437.11	87068801..87069109
IGHG4	14q32.33	REV	IGH		K01316	1481..1800	105161861..105162180	NT_026437.11	87091861..87092180
IGHG4	14q32.33	REV	IGH		K01316	1054..1383	105162278..105162607	NT_026437.11	87092278..87092607
IGHG4	14q32.33	REV	IGH		K01316	900..935	105162726..105162761	NT_026437.11	87092726..87092761
IGHG4	14q32.33	REV	IGH		K01316	216..509	105163154..105163447	NT_026437.11	87093154..87093447
IGHG2	14q32.33	REV	IGH		J00230	1480..1799	105180588..105180907	NT_026437.11	87110588..87110907
IGHG2	14q32.33	REV	IGH		J00230	1056..1382	105181005..105181331	NT_026437.11	87111005..87111331
IGHG2	14q32.33	REV	IGH		J00230	902..937	105181450..105181485	NT_026437.11	87111450..87111485
IGHG2	14q32.33	REV	IGH		J00230	216..509	105181878..105182171	NT_026437.11	87111878..87112171
IGHGP	14q32.33	REV	IGH		X06766	1474..1790	105205635..105205947	NT_026437.11	87135635..87135947
IGHGP	14q32.33	REV	IGH		X06766	1047..1376	105206045..105206374	NT_026437.11	87136045..87136374
IGHGP	14q32.33	REV	IGH		X06766	878..928	105206493..105206543	NT_026437.11	87136493..87136543
IGHGP	14q32.33	REV	IGH		X06766	195..488	105206933..105207226	NT_026437.11	87136933..87137226
IGHA1	14q32.33	REV	IGH		J00220	1244..1635	105244553..105244944	NT_026437.11	87174553..87174944
IGHA1	14q32.33	REV	IGH		J00220	662..1021	105245167..105245526	NT_026437.11	87175167..87175526
IGHA1	14q32.33	REV	IGH		J00220	142..447	105245741..105246046	NT_026437.11	87175741..87176046
IGHEP1	14q32.33	REV	IGH		J00223	849..1177	105259179..105259507	NT_026437.11	87189179..87189507
IGHEP1	14q32.33	REV	IGH		J00223	447..765	105259591..105259909	NT_026437.11	87189591..87189909
IGHG1	14q32.33	REV	IGH		J00228	1481..1800	105278858..105279177	NT_026437.11	87208858..87209177
IGHG1	14q32.33	REV	IGH		J00228	1055..1384	105279275..105279604	NT_026437.11	87209275..87209604
IGHG1	14q32.33	REV	IGH		J00228	892..936	105279723..105279767	NT_026437.11	87209723..87209767
IGHG1	14q32.33	REV	IGH		J00228	210..503	105280159..105280452	NT_026437.11	87210159..87210452
IGHG3	14q32.33	REV	IGH		X03604	2061..2380	105306622..105306941	NT_026437.11	87236622..87236941
IGHG3	14q32.33	REV	IGH		X03604	1634..1963	105307039..105307368	NT_026437.11	87237039..87237368
IGHG3	14q32.33	REV	IGH		X03604	1471..1515	105307487..105307531	NT_026437.11	87237487..87237531
IGHG3	14q32.33	REV	IGH		X03604	1283..1327	105307675..105307719	NT_026437.11	87237675..87237719
IGHG3	14q32.33	REV	IGH		X03604	1095..1139	105307863..105307907	NT_026437.11	87237863..87237907
IGHG3	14q32.33	REV	IGH		X03604	901..951	105308051..105308101	NT_026437.11	87238051..87238101
IGHG3	14q32.33	REV	IGH		X03604	216..509	105308494..105308787	NT_026437.11	87238494..87238787

IGHD	14q32.33	REV	IGH		K02880	25..50	105375785..105375810	NT_026437.11	87305785..87305810
IGHD	14q32.33	REV	IGH		K02879	101..424	105377748..105378071	NT_026437.11	87307748..87308071
IGHD	14q32.33	REV	IGH		K02878	101..424	105378282..105378605	NT_026437.11	87308282..87308605
IGHD	14q32.33	REV	IGH		K02877	101..172	105379342..105379413	NT_026437.11	87309342..87309413
IGHD	14q32.33	REV	IGH		K02876	101..202	105382203..105382304	NT_026437.11	87312203..87312304
IGHD	14q32.33	REV	IGH		K02875	101..403	105382753..105383055	NT_026437.11	87312753..87313055
IGHM	14q32.33	REV	IGH		X14940	1708..2096	105391496..105391887	NT_026437.11	87321496..87321887
IGHM	14q32.33	REV	IGH		X14940	1212..1529	105392067..105392384	NT_026437.11	87322067..87322384
IGHM	14q32.33	REV	IGH		X14940	631..966	105392630..105392965	NT_026437.11	87322630..87322965
IGHM	14q32.33	REV	IGH		X14940	233..544	105393056..105393367	NT_026437.11	87323056..87323367
IGHJ6	14q32.33	REV	IGH	960175..960275	J00256	2909..3009	105400453..105400553	NT_026437.11	87330453..87330553
IGHJ3P	14q32.33	REV	IGH	959970..960057	J00256	2709..2797	105400671..105400758	NT_026437.11	87330671..87330758
IGHJ5	14q32.33	REV	IGH	959571..959659	J00256	2317..2404	105401084..105401156	NT_026437.11	87331069..87331141
IGHJ4	14q32.33	REV	IGH	959172..959258	J00256	1873..1959	105401470..105401556	NT_026437.11	87331470..87331556
IGHJ3	14q32.33	REV	IGH	958789..958886	J00256	1498..1586	105401865..105401930	NT_026437.11	87331842..87331907
IGHJ2P	14q32.33	REV	IGH	958583..958682	J00256	1284..1380	105402046..105402145	NT_026437.11	87332046..87332145
IGHJ2	14q32.33	REV	IGH	958184..958274	J00256	893..984	105402454..105402544	NT_026437.11	87332454..87332544
IGHJ1	14q32.33	REV	IGH	957977..958066	J00256	686..774	105402662..105402751	NT_026437.11	87332662..87332751
IGHD7-27	14q32.33	REV	IGH	957884..957950	J00256	592..659	105402781..105402845	NT_026437.11	87332778..87332842
IGHJ1P	14q32.33	REV	IGH	957759..957849	J00256	467..557	105402879..105402969	NT_026437.11	87332879..87332969
IGHD1-26	14q32.33	REV	IGH	942598..942673	X97051	72141..72216	105417909..105417984	NT_026437.11	87347909..87347984
IGHD6-25	14q32.33	REV	IGH	942095..942168	X97051	71638..71711	105418414..105418487	NT_026437.11	87348414..87348487
IGHD5-24	14q32.33	REV	IGH	939730..939805	X97051	69272..69347	105420778..105420853	NT_026437.11	87350778..87350853
IGHD4-23	14q32.33	REV	IGH	938765..938839	X97051	68306..68380	105421745..105421819	NT_026437.11	87351745..87351819
IGHD3-22	14q32.33	REV	IGH	937592..937678	X93616	2..88	105422906..105422992	NT_026437.11	87352906..87352992
IGHD2-21	14q32.33	REV	IGH	935075..935158	J00235	1..63	105425447..105425509	NT_026437.11	87355447..87355509
IGHD1-20	14q32.33	REV	IGH	932446..932518	X97051	61987..62059	105428066..105428138	NT_026437.11	87358066..87358138
IGHD6-19	14q32.33	REV	IGH	931934..932010	X97051	61475..61551	105428574..105428650	NT_026437.11	87358574..87358650
IGHD5-18	14q32.33	REV	IGH	930093..930168	X13972	2885..2960	105430417..105430492	NT_026437.11	87360417..87360492
IGHD4-17	14q32.33	REV	IGH	929131..929202	X97051	58671..58742	105431383..105431454	NT_026437.11	87361383..87361454
IGHD3-16	14q32.33	REV	IGH	927984..928076	X93614	2..94	105432511..105432601	NT_026437.11	87362511..87362601
IGHD2-15	14q32.33	REV	IGH	925668..925753	J00234	1..66	105434853..105434918	NT_026437.11	87364853..87364918
IGHD1-14	14q32.33	REV	IGH	923001..923073	X13972	14490..14562	105437513..105437585	NT_026437.11	87367513..87367585
IGHD6-13	14q32.33	REV	IGH	922493..922569	X13972	13983..14059	105438017..105438093	NT_026437.11	87368017..87368093
IGHD5-12	14q32.33	REV	IGH	920984..921062	X13972	12478..12556	105439524..105439602	NT_026437.11	87369524..87369602
IGHD4-11	14q32.33	REV	IGH	920024..920095	X13972	11522..11593	105440491..105440562	NT_026437.11	87370491..87370562
IGHD3-10	14q32.33	REV	IGH	919128..919214	X13972	10631..10717	105441372..105441458	NT_026437.11	87371372..87371458
IGHD3-9	14q32.33	REV	IGH	918944..919030	X13972	10447..10533	105441556..105441642	NT_026437.11	87371556..87371642
IGHD2-8	14q32.33	REV	IGH	916414..916500	X13972	7921..8007	105444086..105444172	NT_026437.11	87374086..87374172
IGHD1-7	14q32.33	REV	IGH	913731..913803	X13972	5238..5310	105446783..105446855	NT_026437.11	87376783..87376855
IGHD6-6	14q32.33	REV	IGH	913227..913300	X13972	4734..4807	105447287..105447359	NT_026437.11	87377286..87377358

IGHD5-5	14q32.33	REV	IGH	911378..911453	X97051	59633..59708	105449133..105449208	NT_026437.11	87379133..87379208
IGHD4-4	14q32.33	REV	IGH	910417..910488	X13972	1924..1995	105450098..105450169	NT_026437.11	87380098..87380169
IGHD3-3	14q32.33	REV	IGH	909265..909351	X13972	776..862	105451235..105451321	NT_026437.11	87381235..87381321
IGHD2-2	14q32.33	REV	IGH	906798..906884	J00232	1..66	105453723..105453788	NT_026437.11	87383723..87383788
IGHD1-1	14q32.33	REV	IGH	904136..904208	X97051	33686..33758	105456378..105456450	NT_026437.11	87386378..87386450
IGHV4-30-2	14q32.33	REV	IGH		L10089	1..297	105476885..105476952	NT_026437.11	87406660..87406727
IGHV4-4	14q32.33	REV	IGH	811002..811472	L10098	1..325	105476906..105476984	NT_026437.11	87406894..87406972
IGHV(II)-1-1	14q32.33	REV	IGH	878294..878475	AB019441	78294..78475	105482111..105482292	NT_026437.11	87412111..87412292
IGHV3-21	14q32.33	REV	IGH	597417..597909	AB019439	197417..197909	106282330..106282428	NT_026437.11	88211936..88212034
IGHV1-2	14q32.33	REV	IGH	836435..836911	X07448	126..603	105523675..105524151	NT_026437.11	87453675..87454151
IGHV3-41	14q32.33	REV	IGH	390047..390538	M99670	189..680	106119868..106120165	NT_026437.11	88049868..88050165
IGHV1-3	14q32.33	REV	IGH	817860..818336	X62109	21..497	105542250..105542726	NT_026437.11	87472250..87472726
IGHV4-59	14q32.33	REV	IGH	205856..206326	AB019438	1..291	106154301..106154591	NT_026437.11	88084301..88084591
IGHV2-5	14q32.33	REV	IGH	794964..795446	X62111	71..553	105565140..105565622	NT_026437.11	87495140..87495622
IGHV(III)-5-1	14q32.33	REV	IGH	793545..793643	AB019440	193545..193643	105566943..105567041	NT_026437.11	87496943..87497041
IGHV(III)-5-2	14q32.33	REV	IGH	787450..787749	AB019440	187450..187749	105572837..105573136	NT_026437.11	87502837..87503136
IGHV3-6	14q32.33	REV	IGH	777310..777803	M99650	13..506	105582783..105583276	NT_026437.11	87512783..87513276
IGHV3-7	14q32.33	REV	IGH	770688..771182	M99649	184..678	105589404..105589898	NT_026437.11	87519404..87519898
IGHV6-1	14q32.33	REV	IGH	883485..883971	J04097	337..823	105763091..105763163	NT_026437.11	87692677..87692749
IGHV3-9	14q32.33	REV	IGH	736812..737296	M99651	132..616	105623290..105623774	NT_026437.11	87553290..87553774
IGHV2-10	14q32.33	REV	IGH	729561..730040	M99647	71..550	105630549..105631025	NT_026437.11	87560549..87561025
IGHV3-11	14q32.33	REV	IGH	715861..716349	M99652	48..536	105644237..105644725	NT_026437.11	87574237..87574725
IGHV(III)-11-1	14q32.33	REV	IGH	712240..712656	AB019440	112240..112656	105647930..105648346	NT_026437.11	87577930..87578346
IGHV1-12	14q32.33	REV	IGH	710238..710527	X92210	191..628	105649911..105650348	NT_026437.11	87579911..87580348
IGHV3-13	14q32.33	REV	IGH	702954..703445	X92217	2..493	105657141..105657632	NT_026437.11	87587141..87587632
IGHV(III)-13-1	14q32.33	REV	IGH	690249..690586	AB019440	90249..90586	105670000..105670337	NT_026437.11	87600000..87600337
IGHV1-14	14q32.33	REV	IGH	686675..687009	AB019440	86675..87009	105673577..105673911	NT_026437.11	87603577..87603911
IGHV3-15	14q32.33	REV	IGH	678769..679269	X92216	2..502	105681317..105681817	NT_026437.11	87611317..87611817
IGHV(II)-15-1	14q32.33	REV	IGH	669050..669320	AB019440	69050..69320	105691266..105691536	NT_026437.11	87621266..87621536
IGHV3-16	14q32.33	REV	IGH	667196..667688	M99655	30..522	105692898..105693390	NT_026437.11	87622898..87623390
IGHV(III)-16-1	14q32.33	REV	IGH	661801..662105	AB019440	61801..62105	105698481..105698785	NT_026437.11	87628481..87628785
IGHV1-17	14q32.33	REV	IGH	658074..658549	M99640	45..521	105702037..105702512	NT_026437.11	87632037..87632512
IGHV1-18	14q32.33	REV	IGH	647544..648019	M99641	47..522	105712567..105713042	NT_026437.11	87642567..87643042
IGHV3-19	14q32.33	REV	IGH	635792..636211	M99656	211..630	105724375..105724794	NT_026437.11	87654375..87654794
IGHV3-20	14q32.33	REV	IGH	621508..622001	M99657	10..504	105738585..105739078	NT_026437.11	87668585..87669078
IGHV(II)-20-1	14q32.33	REV	IGH	619576..620076	AB019440	19576..20076	105740510..105741010	NT_026437.11	87670510..87671010
IGHV1-58	14q32.33	REV	IGH	210733..211209	M29809	151..627	106149377..106149853	NT_026437.11	88079377..88079853
IGHV3-22	14q32.33	REV	IGH	574720..575220	M99659	85..585	105785366..105785866	NT_026437.11	87715366..87715866

IGHV(II)-22-1	14q32.33	REV	IGH	569320..569588	AB019439	169320..169588	105790998..105791266	NT_026437.11	87720998..87721266
IGHV(III)-22-2	14q32.33	REV	IGH	568065..568262	AB019439	168065..168262	105792324..105792521	NT_026437.11	87722324..87722521
IGHV3-23	14q32.33	REV	IGH	563887..564381	M99660	10..504	105796205..105796699	NT_026437.11	87726205..87726699
IGHV1-24	14q32.33	REV	IGH	555962..556438	M99642	68..544	105804148..105804624	NT_026437.11	87734148..87734624
IGHV3-25	14q32.33	REV	IGH	543468..543960	M99661	78..570	105816626..105817118	NT_026437.11	87746626..87747118
IGHV(III)-25-1	14q32.33	REV	IGH	539140..539381	AB019439	139140..139381	105821205..105821446	NT_026437.11	87751205..87751446
IGHV2-26	14q32.33	REV	IGH	531449..531931	M99648	21..503	105828655..105829137	NT_026437.11	87758655..87759137
IGHV(III)-26-1	14q32.33	REV	IGH	523568..523874	AB019439	123568..123874	105836712..105837018	NT_026437.11	87766712..87767018
IGHV(II)-26-2	14q32.33	REV	IGH	518318..518630	AB019439	118318..118630	105841956..105842268	NT_026437.11	87771956..87772268
IGHV7-27	14q32.33	REV	IGH	515042..515455	M99643	65..526	105845083..105845544	NT_026437.11	87775083..87775544
IGHV4-31	14q32.33	REV	IGH	483897..484373	X05713	153..626	105851517..105851990	NT_026437.11	87781517..87781990
IGHV(II)-28-1	14q32.33	REV	IGH	503603..503855	AB019439	103603..103855	105856731..105856983	NT_026437.11	87786731..87786983
IGHV3-29	14q32.33	REV	IGH	501726..502222	AB019439	101726..102222	105858364..105858860	NT_026437.11	87788364..87788860
IGHV3-30	14q32.33	REV	IGH	498085..498577	M83134	1782..2274	105862009..105862501	NT_026437.11	87792009..87792501
IGHV(II)-30-1	14q32.33	REV	IGH	490666..490939	AB019439	90666..90939	105869647..105869920	NT_026437.11	87799647..87799920
IGHV3-30-2	14q32.33	REV	IGH	488784..489232	AB019439	88784..89232	105871354..105871802	NT_026437.11	87801354..87801802
IGHV4-28	14q32.33	REV	IGH	508596..509069	X05714	151..624	105549114..105549584	NT_026437.11	87479114..87479584
IGHV(II)-31-1	14q32.33	REV	IGH	478924..479232	AB019439	78924..79232	105881354..105881662	NT_026437.11	87811354..87811662
IGHV3-32	14q32.33	REV	IGH	477013..477509	AB019439	77013..77509	105883077..105883573	NT_026437.11	87813077..87813573
IGHV3-33	14q32.33	REV	IGH	473368..473860	AB019439	73368..73860	105886726..105887218	NT_026437.11	87816726..87817218
IGHV(II)-33-1	14q32.33	REV	IGH	465947..466220	AB019439	65947..66220	105894366..105894639	NT_026437.11	87824366..87824639
IGHV3-33-2	14q32.33	REV	IGH	464064..464512	AB019439	64064..64512	105896074..105896522	NT_026437.11	87826074..87826522
IGHV4-34	14q32.33	REV	IGH	459517..459988	AB019439	1..343	105900598..105900940	NT_026437.11	87830598..87830940
IGHV7-34-1	14q32.33	REV	IGH	455877..456349	AB019439	55877..56349	105904237..105904709	NT_026437.11	87834237..87834709
IGHV3-35	14q32.33	REV	IGH	443767..444259	M99666	140..632	105916327..105916819	NT_026437.11	87846327..87846819
IGHV3-36	14q32.33	REV	IGH	440399..440861	M99667	218..681	105919724..105920187	NT_026437.11	87849724..87850187
IGHV3-37	14q32.33	REV	IGH	436515..437003	M99668	10..489	105923586..105924071	NT_026437.11	87853586..87854071
IGHV3-38	14q32.33	REV	IGH	422685..423175	M99669	10..497	105937413..105937901	NT_026437.11	87867413..87867901
IGHV(III)-38-1	14q32.33	REV	IGH	415315..415645	AB019439	15315..15645	105944941..105945271	NT_026437.11	87874941..87875271
IGHV4-30-4	14q32.33	REV	IGH		Z14238	1..438	105876252..105876689	NT_026437.11	87806252..87806689
IGHV7-40	14q32.33	REV	IGH	408075..408316	M99644	164..497	105952270..105952592	NT_026437.11	87882270..87882592
IGHV(II)-40-1	14q32.33	REV	IGH	392620..392696	AB019438	192620..192696	105967890..105967966	NT_026437.11	87897890..87897966
IGHV3-30-3	14q32.33	REV	IGH		X92283	1..294	105970093..105970379	NT_026437.11	87900093..87900378
IGHV3-42	14q32.33	REV	IGH	369925..370362	M99671	1..461	105762906..105763129	NT_026437.11	87692869..87693089
IGHV3-43	14q32.33	REV	IGH	362897..363393	M99672	170..666	105997193..105997689	NT_026437.11	87927193..87927689
IGHV(II)-43-1	14q32.33	REV	IGH	360618..360826	AB019438	160618..160826	105999760..105999968	NT_026437.11	87929760..87929968
IGHV(III)-44	14q32.33	REV	IGH	355142..355318	M99673	62..511	106005056..106005444	NT_026437.11	87935056..87935444

IGHV(IV)-44-1	14q32.33	REV	IGH	343764..344231	AB019438	143764..144231	106016355..106016822	NT_026437.11	87946355..87946822
IGHV(II)-44-2	14q32.33	REV	IGH	339146..339382	AB019438	136146..139382	106021204..106024440	NT_026437.11	87951204..87954440
IGHV1-45	14q32.33	REV	IGH	326175..326651	X92209	2..478	106033935..106034411	NT_026437.11	87963935..87964411
IGHV1-46	14q32.33	REV	IGH	322057..322533	X92343	153..629	106038053..106038529	NT_026437.11	87968053..87968529
IGHV(II)-46-1	14q32.33	REV	IGH	317614..317771	AB019438	117614..117771	106042815..106042972	NT_026437.11	87972815..87972972
IGHV3-47	14q32.33	REV	IGH	314580..315074	Z18900	1..291	106045553..106045843	NT_026437.11	87975553..87975843
IGHV(III)-47-1	14q32.33	REV	IGH	302103..302406	AB019438	102103..102406	106058180..106058483	NT_026437.11	87988180..87988483
IGHV3-48	14q32.33	REV	IGH	295274..295768	M99675	174..668	106064818..106065312	NT_026437.11	87994818..87995312
IGHV3-49	14q32.33	REV	IGH	276144..276644	M99676	224..724	106083946..106084442	NT_026437.11	88013946..88014442
IGHV(II)-49-1	14q32.33	REV	IGH	268955..269225	AB019438	68955..69225	106091361..106091631	NT_026437.11	88021361..88021631
IGHV3-50	14q32.33	REV	IGH	266998..267453	M99677	10..283	106093318..106093588	NT_026437.11	88023316..88023585
IGHV5-51	14q32.33	REV	IGH	254379..254853	M99686	168..641	106105734..106106207	NT_026437.11	88035734..88036207
IGHV(III)-51-1	14q32.33	REV	IGH	249747..250053	AB019438	49747..50053	106110533..106110839	NT_026437.11	88040533..88040839
IGHV(II)-51-2	14q32.33	REV	IGH	248581..248843	AB019438	48581..48843	106111743..106112005	NT_026437.11	88041743..88042005
IGHV3-52	14q32.33	REV	IGH	246731..247220	M99678	212..701	106113366..106113855	NT_026437.11	88043366..88043855
IGHV3-53	14q32.33	REV	IGH	240421..240910	M99679	38..527	106282134..106282436	NT_026437.11	88212134..88212436
IGHV(II)-53-1	14q32.33	REV	IGH	233605..233874	AB019438	33605..33874	106126712..106126981	NT_026437.11	88056712..88056981
IGHV3-54	14q32.33	REV	IGH	231746..232232	M99680	147..631	106128356..106128840	NT_026437.11	88058356..88058840
IGHV4-55	14q32.33	REV	IGH	226980..227454	M99685	230..704	106133132..106133606	NT_026437.11	88063132..88063606
IGHV7-56	14q32.33	REV	IGH	223335..223808	M29810	136..429	106136958..106137251	NT_026437.11	88066958..88067251
IGHV3-57	14q32.33	REV	IGH	214314..214658	M29815	7..568	106146106..106146421	NT_026437.11	88076062..88076381
IGHV1-8	14q32.33	REV	IGH	750026..750503	M99637	58..535	105610083..105610560	NT_026437.11	87540083..87540560
IGHV4-39	14q32.33	REV	IGH	411486..411963	AB019439	1..328	105948662..105948989	NT_026437.11	87878662..87878989
IGHV3-60	14q32.33	REV	IGH	201883..202375	AB019438	1883..2375	106158211..106158703	NT_026437.11	88088211..88088703
IGHV(II)-60-1	14q32.33	REV	IGH	195563..195869	AB019437	195563..195831	106164755..106165023	NT_026437.11	88094755..88095023
IGHV4-61	14q32.33	REV	IGH	193980..194456	M29811	151..628	106166130..106166606	NT_026437.11	88096130..88096606
IGHV3-62	14q32.33	REV	IGH	189953..190447	AB019437	189953..190447	106170139..106170633	NT_026437.11	88100139..88100633
IGHV(II)-62-1	14q32.33	REV	IGH	182749..183060	AB019437	182749..183060	106177526..106177837	NT_026437.11	88107526..88107837
IGHV3-63	14q32.33	REV	IGH	180846..181313	M99681	10..506	106179251..106179740	NT_026437.11	88109251..88109740
IGHV3-64	14q32.33	REV	IGH	175347..175841	M99682	78..575	106184745..106185242	NT_026437.11	88114745..88115242
IGHV3-65	14q32.33	REV	IGH	166993..167487	Z27503	1..301	106193140..106193440	NT_026437.11	88123140..88123440
IGHV(III)-2-1	14q32.33	REV	IGH	821563..821903	AB019441	21563..21903	105538683..105539023	NT_026437.11	87468683..87469023
IGHV(II)-65-1	14q32.33	REV	IGH	161481..161753	AB019437	161481..161753	106198833..106199105	NT_026437.11	88128833..88129105
IGHV3-66	14q32.33	REV	IGH	158060..158549	X92218	2..491	106202037..106202526	NT_026437.11	88132037..88132526
IGHV1-67	14q32.33	REV	IGH	152482..152960	AB019437	1..434	106207626..106208059	NT_026437.11	88137626..88138059
IGHV(II)-67-1	14q32.33	REV	IGH	146982..147131	AB019437	146982..147131	106213455..106213604	NT_026437.11	88143455..88143604
IGHV(III)-67-2	14q32.33	REV	IGH	146324..146422	AB019437	146324..146422	106214164..106214262	NT_026437.11	88144164..88144262

IGHV(III)-67-3	14q32.33	REV	IGH	140636..140910	AB019437	140636..140910	106219676..106219950	NT_026437.11	88149676..88149950
IGHV(III)-67-4	14q32.33	REV	IGH	138127..138432	AB019437	138127..138432	106222154..106222459	NT_026437.11	88152154..88152459
IGHV1-68	14q32.33	REV	IGH	129238..129717	AB019437	129238..129717	106230869..106231348	NT_026437.11	88160869..88161348
IGHV1-69	14q32.33	REV	IGH	119174..119651	L22582	233..710	106240935..106241412	NT_026437.11	88170935..88171412
IGHV2-70	14q32.33	REV	IGH	110279..110761	L21969	1..444	106249864..106250307	NT_026437.11	88179864..88180307
IGHV3-71	14q32.33	REV	IGH	105684..106184	AB019437	105684..106184	106254402..106254902	NT_026437.11	88184402..88184902
IGHV3-72	14q32.33	REV	IGH	90150..90650	X92206	87..587	106269936..106270436	NT_026437.11	88199936..88200436
IGHV3-73	14q32.33	REV	IGH	78150..78650	X70197	1..300	105990226..105990526	NT_026437.11	87920226..87920526
IGHV3-74	14q32.33	REV	IGH	70412..70906	L33851	23..476	106289721..106290174	NT_026437.11	88219721..88220174
IGHV(II)-74-1	14q32.33	REV	IGH	59900..60068	AB019437	59900..60068	106300518..106300686	NT_026437.11	88230518..88230686
IGHV3-75	14q32.33	REV	IGH	57164..57672	Z27510	4..308	106302955..106303259	NT_026437.11	88232955..88233259
IGHV3-76	14q32.33	REV	IGH	53003..53492	AB019437	1..292	106307134..106307425	NT_026437.11	88237134..88237425
IGHV(III)-76-1	14q32.33	REV	IGH	49245..49551	AB019437	49245..49551	106311035..106311341	NT_026437.11	88241035..88241341
IGHV5-78	14q32.33	REV	IGH	29780..30228	X92213	592..1027	106330373..106330806	NT_026437.11	88260373..88260806
IGHV(II)-78-1	14q32.33	REV	IGH	15431..15744	AB019437	15431..15744	106344842..106345155	NT_026437.11	88274842..88275155
IGHV3-79	14q32.33	REV	IGH	13237..13688	AB019437	13237..13688	106346898..106347349	NT_026437.11	88276898..88277349
IGHV4-80	14q32.33	REV	IGH	8147..8547	AB019437	8147..8547	106352039..106352439	NT_026437.11	88282039..88282439
IGHV7-81	14q32.33	REV	IGH	6315..6790	AB019437	6315..6790	106353796..106354271	NT_026437.11	88283796..88284271
IGHV(III)-82	14q32.33	REV	IGH	1490..1781	AB019437	1490..1781	106358805..106359096	NT_026437.11	88288805..88289096

FIG. 21

IMGT Gene	Chromosomal localization	Orientation	NCBI Gene ID	Reference GRCm38.p3 C57BL/6J	NCBI Gene positions in sequence	Orientation sequence	MGI ID	MGI symbol
IGHV1-86	12F2 (62.59 cM)	REV	668599	NC_000078.6	116009659..116009954	-1	MGI:3645729	Ighv1-86
IGHV1-85	12F2 (62.59 cM)	REV	668597	NC_000078.6	116000028..116000321	-1	MGI:3645723	Ighv1-85
IGHV1-84	12F2 (62.59 cM)	REV	434609	NC_000078.6	115980702..115981134	-1	MGI:3644235	Ighv1-84
IGHV1-83	12F2 (62.59 cM)	REV	620140	NC_000078.6	115963817..115964109	-1	MGI:3648939	Ighv1-83
IGHV1-82	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115952538..115952831	-1	MGI:4439671	Ighv1-82
IGHV1-81	12F2 (62.59 cM)	REV	668591	NC_000078.6	115920279..115920572	-1	MGI:4439635	Ighv1-81
IGHV1-80	12F2 (62.59 cM)	REV	668589	NC_000078.6	115912344..115912637	-1	MGI:4439738	Ighv1-80
IGHV1-79	12F2 (62.59 cM)	REV	435331	NC_000078.6	115888096..115888389	-1	MGI:3648258	Ighv1-79
IGHV1-78	12F2 (62.59 cM)	REV	213570	NC_000078.6	115868773..115869066	-1	MGI:4439736	Ighv1-78
IGHV1-77	12F2 (62.59 cM)	REV	619994	NC_000078.6	115861867..115862160	-1	MGI:4439670	Ighv1-77
IGHV8-16	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115858008..115858301	-1	MGI:5434409	Ighv8-16
IGHV1-76	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115847881..115848174	-1	MGI:4439737	Ighv1-76
IGHV8-15	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115844016..115844309	-1	MGI:5434408	Ighv8-15
IGHV1-75	12F2 (62.59 cM)	REV	622728	NC_000078.6	115833950..115834243	-1	MGI:4439735	Ighv1-75
IGHV8-14	12F2 (62.59 cM)	REV	668582	NC_000078.6	115808427..115808727	-1	MGI:3648977	Ighv8-14
IGHV1-74	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115802690..115803080	-1	MGI:4439634	Ighv1-74
IGHV1-73	12F2 (62.59 cM)	REV	668577	NC_000078.6	115790593..115790887	-1	MGI:3645131	Ighv1-73
IGHV8-13	12F2 (62.59 cM)	REV	1.01E+08	NC_000078.6	115765335..115765635	-1	MGI:4439734	Ighv8-13
IGHV1-72	12F2 (62.59 cM)	REV	619916	NC_000078.6	115757984..115758277	-1	MGI:4439633	Ighv1-72
IGHV1-71	12F2 (62.59 cM)	REV	619886	NC_000078.6	115742205..115742506	-1	MGI:3643033	Ighv1-71
IGHV1-70	12F2 (62.59 cM)	REV	638634	NC_000078.6	115691889..115692182	-1	MGI:3644620	Ighv1-70
IGHV8-12	12F2 (62.59 cM)	REV	780960	NC_000078.6	115647945..115648245	-1	MGI:3642873	Ighv8-12
IGHV1-69	12F2 (62.59 cM)	REV	619833	NC_000078.6	115623203..115623595	-1	MGI:4439632	Ighv1-69

IGHV1-68	12F2 (62.59 cM)	REV	780959	NC_000078.6	115611340..115611633	-1	MGI:5009923	Ighv1-68
IGHV1-67	12F2 (62.59 cM)	REV	435328	NC_000078.6	115603940..115604233	-1	MGI:3645228	Ighv1-67
IGHV1-66	12F2 (62.59 cM)	REV	380824	NC_000078.6	115593110..115593403	-1	MGI:4439825	Ighv1-66
IGHV8-11	12F2 (62.59 cM)	REV	636462	NC_000078.6	115567149..115567449	-1	MGI:3644925	Ighv8-11
IGHV1-65	12F2 (62.58 cM)	REV	780958	NC_000078.6	115532055..115532347	-1	MGI:5009922	Ighv1-65
IGHV8-10	12F2 (62.58 cM)	REV	780957	NC_000078.6	115519340..115519640	-1	MGI:5009921	Ighv8-10
IGHV1-64	12F2 (62.58 cM)	REV	380823	NC_000078.6	115507587..115507977	-1	MGI:4439789	Ighv1-64
IGHV1-63	12F2 (62.58 cM)	REV	780956	NC_000078.6	115495625..115496058	-1	MGI:3642755	Ighv1-63
IGHV8-9	12F2 (62.57 cM)	REV	432709	NC_000078.6	115468331..115468632	-1	MGI:3644475	Ighv8-9
IGHV1-62-3	12F2 (62.57 cM)	REV	668549	NC_000078.6	115460999..115461431	-1	MGI:3648544	Ighv1-62-3
IGHV1-62-2	12F2 (62.57 cM)	REV	238448	NC_000078.6	115446417..115446710	-1	MGI:3644968	Ighv1-62-2
IGHV1-62-1	12F2 (62.55 cM)	REV	668544	NC_000078.6	115386707..115386988	-1	MGI:3704125	Ighv1-62-1
IGHV1-62	12F2 (62.55 cM)	REV	668542	NC_000078.6	115371986..115372278	-1	MGI:5009844	Ighv1-62
IGHV1-61	12F2 (62.55 cM)	REV	674018	NC_000078.6	115359140..115359433	-1	MGI:4439824	Ighv1-61
IGHV1-60	12F2 (62.55 cM)	REV	780940	NC_000078.6	115344537..115344830	-1	MGI:5009920	Ighv1-60
IGHV1-59	12F2 (62.54 cM)	REV	432708	NC_000078.6	115335057..115335513	-1	MGI:3644474	Ighv1-59
IGHV1-58	12F2 (62.54 cM)	REV	780939	NC_000078.6	115312166..115312597	-1	MGI:4439557	Ighv1-58
IGHV8-8	12F2 (62.54 cM)	REV	780938	NC_000078.6	115294066..115294362	-1	MGI:3815333	Ighv8-8
IGHV1-57	12F2 (62.53 cM)	REV	780937	NC_000078.6	115268424..115268715	-1	MGI:5009919	Ighv1-57
IGHV8-7	12F2 (62.53 cM)	REV	780936	NC_000078.6	115258139..115258432	-1	MGI:5009918	Ighv8-7
IGHV1-56	12F2 (62.53 cM)	REV	382695	NC_000078.6	115242802..115243095	-1	MGI:4439715	Ighv1-56
IGHV1-55	12F2 (62.52 cM)	REV	780932	NC_000078.6	115208137..115208527	-1	MGI:4439716	Ighv1-55
IGHV1-54	12F2 (62.52 cM)	REV	211331	NC_000078.6	115193675..115193968	-1	MGI:3647133	Ighv1-54
IGHV8-6	12F2 (62.51 cM)	REV	629930	NC_000078.6	115165777..115166077	-1	MGI:3645823	Ighv8-6
IGHV1-53	12F2 (62.51 cM)	REV	780931	NC_000078.6	115158445..115158835	-1	MGI:3576502	Ighv1-53
IGHV1-52	12F2 (62.51 cM)	REV	382696	NC_000078.6	115145487..115145780	-1	MGI:4439752	Ighv1-52
IGHV1-51	12F2 (62.51 cM)	REV	780930	NC_000078.6	115131375..115131668	-1	MGI:5009917	Ighv1-51
IGHV1-50	12F2 (62.5 cM)	REV	780929	NC_000078.6	115119748..115120041	-1	MGI:4439753	Ighv1-50
IGHV8-5	12F2 (62.49 cM)	REV	640506	NC_000078.6	115067560..115067860	-1	MGI:3645478	Ighv8-5
IGHV1-49	12F2 (62.49 cM)	REV	629925	NC_000078.6	115055223..115055516	-1	MGI:4439754	Ighv1-49

IGHV1-48	12F2 (62.49 cM)	REV	780928	NC_000078.6	115038227..115038520	-1	MGI:5009916	Ighv1-48	
IGHV8-4	12F2 (62.48 cM)	REV	629919	NC_000078.6	115024026..115024318	-1	MGI:3646040	Ighv8-4	
IGHV8-3	12F2 (62.48 cM)	REV	780927	NC_000078.6	115003418..115003712	-1	MGI:5009915	Ighv8-3	
IGHV1-47	12F2 (62.48 cM)	REV	629915	NC_000078.6	114991108..114991401	-1	MGI:4439890	Ighv1-47	
IGHV1-46	12F2 (62.48 cM)	REV	668522	NC_000078.6	114977693..114977986	-1	MGI:5009843	Ighv1-46	
IGHV1-45	12F2 (62.47 cM)	REV	780894	NC_000078.6	114970055..114970348	-1	MGI:5009913	Ighv1-45	
IGHV1-44	12F2 (62.47 cM)	REV	668521	NC_000078.6	114963380..114963674	-1	MGI:5009842	Ighv1-44	
IGHV1-43	12F2 (62.47 cM)	REV	629908	NC_000078.6	114945950..114946243	-1	MGI:3704124	Ighv1-43	
IGHV1-42	12F2 (62.47 cM)	REV	629906	NC_000078.6	114937154..114937544	-1	MGI:3704123	Ighv1-42	
IGHV1-41	12F2 (62.47 cM)	REV	629904	NC_000078.6	114932371..114932664	-1	MGI:3649084	Ighv1-41	
IGHV1-40	12F2 (62.47 cM)	REV	780892	NC_000078.6	114924941..114925233	-1	MGI:5009912	Ighv1-40	
IGHV1-39	12F2 (62.46 cM)	REV	780891	NC_000078.6	114914599..114914892	-1	MGI:4439888	Ighv1-39	
IGHV1-38	12F2 (62.46 cM)	REV	780890	NC_000078.6	114910011..114910303	-1	MGI:5009911	Ighv1-38	
IGHV1-37	12F2 (62.46 cM)	REV	668517	NC_000078.6	114896238..114896531	-1	MGI:4439640	Ighv1-37	
IGHV1-36	12F2 (62.46 cM)	REV	629897	NC_000078.6	114879888..114880181	-1	MGI:4439639	Ighv1-36	
IGHV1-35	12F2 (62.46 cM)	REV	668515	NC_000078.6	114875302..114875597	-1	MGI:3644935	Ighv1-35	
IGHV1-34	12F2 (62.45 cM)	REV	628614	NC_000078.6	114851190..114851483	-1	MGI:4439659	Ighv1-34	
IGHV1-33	12F2 (62.45 cM)	REV	641247	NC_000078.6	114843693..114844083	-1	MGI:4439617	Ighv1-33	
IGHV1-32	12F2 (62.45 cM)	REV	780888	NC_000078.6	114835223..114835516	-1	MGI:5009910	Ighv1-32	
IGHV1-31	12F2 (62.45 cM)	REV	629893	NC_000078.6	114829264..114829557	-1	MGI:4439889	Ighv1-31	
IGHV1-30	12F2 (62.44 cM)	REV	668511	NC_000078.6	114817099..114817390	-1	MGI:4937173	Ighv1-30	
IGHV1-29	12F2 (62.44 cM)	REV	780887	NC_000078.6	114812321..114812605	-1	MGI:5009909	Ighv1-29	
IGHV1-28	12F2 (62.44 cM)	REV	668510	NC_000078.6	114809421..114809714	-1	MGI:3644938	Ighv1-28	
IGHV1-27	12F2 (62.44 cM)	REV	780886	NC_000078.6	114804616..114804909	-1	MGI:5009908	Ighv1-27	
IGHV1-26	12F2 (62.44 cM)	REV	629884	NC_000078.6	114788372..114788665	-1	MGI:4439641	Ighv1-26	
IGHV1-25	12F2 (62.44 cM)	REV	640497	NC_000078.6	114781409..114781702	-1	MGI:3648295	Ighv1-25	
IGHV1-24	12F2 (62.44 cM)	REV	780885	NC_000078.6	114772928..114773221	-1	MGI:3815052	Ighv1-24	
IGHV1-23	12F2 (62.43 cM)	REV	780884	NC_000078.6	114764450..114764743	-1	MGI:3815050	Ighv1-23	
IGHV1-22	12F2 (62.43 cM)	REV	780883	NC_000078.6	114746273..114746566	-1	MGI:4439784	Ighv1-22	
IGHV1-21	12F2 (62.43 cM)	REV	668499	NC_000078.6	114740383..114740840	-1	MGI:5009841	Ighv1-21	

IGHV1-21-1	12F2 (62.43 cM)	REV	631595	NC_000078.6	114736245..114736538	-1	MGI:3645737	Ighv1-21-1
IGHV1-20	12F2 (62.43 cM)	REV	668497	NC_000078.6	114723772..114724065	-1	MGI:3644607	Ighv1-20
IGHV1-19	12F2 (62.42 cM)	REV	382692	NC_000078.6	114708648..114708941	-1	MGI:4439779	Ighv1-19
IGHV1-19-1	12F2 (62.42 cM)	REV	668493	NC_000078.6	114704147..114704440	-1	MGI:3644603	Ighv1-19-1
IGHV1-18	12F2 (62.42 cM)	REV	629871	NC_000078.6	114682632..114682925	-1	MGI:4439780	Ighv1-18
IGHV1-17	12F2 (62.42 cM)	REV	629869	NC_000078.6	114676749..114677042	-1	MGI:3647700	Ighv1-17
IGHV1-17-1	12F2 (62.42 cM)	REV	780926	NC_000078.6	114671968..114672262	-1	MGI:5009914	Ighv1-17-1
IGHV1-16	12F2 (62.42 cM)	REV	629866	NC_000078.6	114665872..114666165	-1	MGI:3647704	Ighv1-16
IGHV1-15	12F2 (62.41 cM)	REV	629865	NC_000078.6	114657353..114657646	-1	MGI:4439782	Ighv1-15
IGHV1-14	12F2 (62.41 cM)	REV	629863	NC_000078.6	114646572..114646865	-1	MGI:4439781	Ighv1-14
IGHV1-13	12F2 (62.41 cM)	REV	780865	NC_000078.6	114630680..114630973	-1	MGI:5009907	Ighv1-13
IGHV1-12	12F2 (62.41 cM)	REV	629860	NC_000078.6	114615850..114616143	-1	MGI:3646284	Ighv1-12
IGHV1-11	12F2 (62.41 cM)	REV	629859	NC_000078.6	114612244..114612536	-1	MGI:5009835	Ighv1-11
IGHV1-10	12F2 (62.40 cM)	REV	637050	NC_000078.6	114597878..114598175	-1	MGI:5009837	Ighv1-10
IGHV1-9	12F2 (62.40 cM)	REV	668478	NC_000078.6	114583569..114583862	-1	MGI:4439621	Ighv1-9
IGHV15-2	12F2 (62.40 cM)	REV	780864	NC_000078.6	114564578..114564874	-1	MGI:4947963	Ighv15-2
IGHV1-8	12F2 (62.39 cM)	REV	780863	NC_000078.6	114555610..114555902	-1	MGI:5009906	Ighv1-8
IGHV10-4	12F2 (62.39 cM)	REV	780862	NC_000078.6	114547258..114547556	-1	MGI:5009905	Ighv10-4
IGHV1-7	12F2 (62.39 cM)	REV	668474	NC_000078.6	114538495..114538788	-1	MGI:3704122	Ighv1-7
IGHV1-6	12F2 (62.39 cM)	REV	780861	NC_000078.6	114532972..114533264	-1	MGI:5009904	Ighv1-6
IGHV10-3	12F2 (62.39 cM)	REV	380809	NC_000078.6	114523441..114523887	-1	MGI:3648785	Ighv10-3
IGHV1-5	12F2 (62.39 cM)	REV	668469	NC_000078.6	114513330..114513623	-1	MGI:3704121	Ighv1-5
IGHV10-2	12F2 (62.38 cM)	REV	780860	NC_000078.6	114496003..114496300	-1	MGI:5009903	Ighv10-2
IGHV1-4	12F2 (62.38 cM)	REV	432702	NC_000078.6	114487136..114487429	-1	MGI:4439618	Ighv1-4
IGHV1-3	12F2 (62.38 cM)	REV	780859	NC_000078.6	114481615..114481916	-1	MGI:5009902	Ighv1-3
IGHV10-1	12F2 (62.38 cM)	REV	380808	NC_000078.6	114479007..114479451	-1	MGI:4439620	Ighv10-1
IGHV1-2	12F2 (62.38 cM)	REV	238428	NC_000078.6	114469075..114469371	-1	MGI:4439924	Ighv1-2
IGHV8-2	12F2 (62.38 cM)	REV	629849	NC_000078.6	114462290..114462589	-1	MGI:3647474	Ighv8-2
IGHV6-7	12F2 (62.38 cM)	REV	432701	NC_000078.6	114455626..114455925	-1	MGI:3644477	Ighv6-7
IGHV6-6	12F2 (62.37 cM)	REV	238427	NC_000078.6	114434788..114435087	-1	MGI:4439619	Ighv6-6

IGHV6-5	12F2 (62.37 cM)	REV	639510	NC_000078.6	114416596..114416895	-1	MGI:3647134	Ighv6-5
IGHV6-4	12F2 (62.37 cM)	REV	628398	NC_000078.6	114406474..114406773	-1	MGI:3704120	Ighv6-4
IGHV6-3	12F2 (62.36 cM)	REV	629845	NC_000078.6	114391712..114392010	-1	MGI:4439854	Ighv6-3
IGHV12-3	12F2 (62.36 cM)	REV	435321	NC_000078.6	114366526..114366819	-1	MGI:3646760	Ighv12-3
IGHV13-2	12F2 (62.36 cM)	REV	629842	NC_000078.6	114357761..114358060	-1	MGI:3705861	Ighv13-2
IGHV1-1	12F2 (62.36 cM)	REV	780834	NC_000078.6	114351705..114351995	-1	MGI:5009901	Ighv1-1
IGHV8-1	12F2 (62.35 cM)	REV	780833	NC_000078.6	114332796..114333086	-1	MGI:5009900	Ighv8-1
IGHV3-8	12F2 (62.35 cM)	REV	780831	NC_000078.6	114322376..114322666	-1	MGI:3645298	Ighv3-8
IGHV5-21	12F2 (62.35 cM)	REV	780832	NC_000078.6	114320030..114320324	-1	MGI:5009899	Ighv5-21
IGHV3-7	12F2 (62.35 cM)	REV	780830	NC_000078.6	114314186..114314479	-1	MGI:5009898	Ighv3-7
IGHV9-4	12F2 (62.34 cM)	REV	636260	NC_000078.6	114299961..114300254	-1	MGI:3646379	Ighv9-4
IGHV3-6	12F2 (62.34 cM)	REV	780829	NC_000078.6	114288152..114288447	-1	MGI:4439856	Ighv3-6
IGHV13-1	12F2 (62.33 cM)	REV	780828	NC_000078.6	114267607..114267906	-1	MGI:4439855	Ighv13-1
IGHV3-5	12F2 (62.33 cM)	REV	633457	NC_000078.6	114262652..114262950	-1	MGI:3648045	Ighv3-5
IGHV3-4	12F2 (62.33 cM)	REV	629833	NC_000078.6	114253617..114253915	-1	MGI:3644034	Ighv3-4
IGHV7-4	12F2 (62.32 cM)	REV	632654	NC_000078.6	114222788..114223254	-1	MGI:4439763	Ighv7-4
IGHV3-3	12F2 (62.31 cM)	REV	668438	NC_000078.6	114196439..114196875	-1	MGI:3643949	Ighv3-3
IGHV14-4	12F2 (62.30 cM)	REV	629826	NC_000078.6	114176438..114176867	-1	MGI:4439765	Ighv14-4
IGHV15-1	12F2 (62.30 cM)	REV	780827	NC_000078.6	114158025..114158315	-1	MGI:5009897	Ighv15-1
IGHV7-3	12F2 (62.30 cM)	REV	629822	NC_000078.6	114153180..114153644	-1	MGI:4439766	Ighv7-3
IGHV9-3	12F2 (62.29 cM)	REV	780825	NC_000078.6	114140692..114141122	-1	MGI:3642720	Ighv9-3
IGHV12-2	12F2 (62.29 cM)	REV	780824	NC_000078.6	114127533..114127984	-1	MGI:5009896	Ighv12-2
IGHV9-2	12F2 (62.28 cM)	REV	629818	NC_000078.6	114109001..114109430	-1	MGI:3643816	Ighv9-2
IGHV12-1	12F2 (62.28 cM)	REV	780823	NC_000078.6	114107259..114107563	-1	MGI:5295669	Ighv12-1
IGHV9-1	12F2 (62.28 cM)	REV	195180	NC_000078.6	114093928..114094221	-1	MGI:4439911	Ighv9-1
IGHV6-2	12F2 (62.28 cM)	REV	780822	NC_000078.6	114089387..114089681	-1	MGI:5009895	Ighv6-2
IGHV16-1	12F2 (62.27 cM)	REV	629812	NC_000078.6	114068828..114069126	-1	MGI:3643819	Ighv16-1
IGHV14-3	12F2 (62.27 cM)	REV	238418	NC_000078.6	114059845..114060273	-1	MGI:4439764	Ighv14-3
IGHV11-2	12F2 (62.27 cM)	REV	780818	NC_000078.6	114048241..114048704	-1	MGI:4947968	Ighv11-2
IGHV3-2	12F2 (62.26 cM)	REV	780817	NC_000078.6	114033803..114034097	-1	MGI:4439923	Ighv3-2

IGHV4-2	12F2 (62.26 cM)	REV	668423	NC_000078.6	114013144..114013439	-1	MGI:5009840	Ighv4-2
IGHV14-2	12F2 (62.25 cM)	REV	668421	NC_000078.6	113994469..113994898	-1	MGI:4439607	Ighv14-2
IGHV11-1	12F2 (62.25 cM)	REV	780804	NC_000078.6	113981879..113982174	-1	MGI:4439535	Ighv11-1
IGHV3-1	12F2 (62.24 cM)	REV	780803	NC_000078.6	113964390..113964683	-1	MGI:4439534	Ighv3-1
IGHV4-1	12F2 (62.24 cM)	REV	780802	NC_000078.6	113948284..113948577	-1	MGI:4439536	Ighv4-1
IGHV14-1	12F2 (62.23 cM)	REV	780801	NC_000078.6	113931953..113932246	-1	MGI:4439920	Ighv14-1
IGHV7-2	12F2 (62.23 cM)	REV	780800	NC_000078.6	113912025..113912483	-1	MGI:4439623	Ighv7-2
IGHV7-1	12F2 (62.22 cM)	REV	780799	NC_000078.6	113896408..113896946	-1	MGI:4439622	Ighv7-1
IGHV5-19	12F2 (62.22 cM)	REV	780798	NC_000078.6	113884761..113885342	-1	MGI:5009894	Ighv5-19
IGHV2-9	12F2 (62.22 cM)	REV	640046	NC_000078.6	113879097..113879388	-1	MGI:4439624	Ighv2-9
IGHV2-8	12F2 (62.22 cM)	REV	780797	NC_000078.6	113877361..113877659	-1	MGI:5009893	Ighv2-8
IGHV5-18	12F2 (62.22 cM)	REV	780796	NC_000078.6	113875772..113876239	-1	MGI:5009892	Ighv5-18
IGHV5-17	12F2 (62.21 cM)	REV	780794	NC_000078.6	113859149..113859442	-1	MGI:4439533	Ighv5-17
IGHV5-16	12F2 (62.21 cM)	REV	633568	NC_000078.6	113838528..113838821	-1	MGI:4439556	Ighv5-16
IGHV5-15	12F2 (62.20 cM)	REV	780792	NC_000078.6	113826648..113826941	-1	MGI:4439812	Ighv5-15
IGHV2-7	12F2 (62.20 cM)	REV	780793	NC_000078.6	113807314..113807747	-1	MGI:4439521	Ighv2-7
IGHV2-6-8	12F2 (62.19 cM)	REV	791090	NC_000078.6	113796138..113796430	-1	MGI:4439811	Ighv2-6-8
IGHV2-9-1	12F2 (62.18 cM)	REV	791089	NC_000078.6	113769857..113770142	-1	MGI:4439519	Ighv2-9-1
IGHV5-12-4	12F2 (62.18 cM)	REV	628098	NC_000078.6	113762251..113762544	-1	MGI:3645977	Ighv5-12-4
IGHV5-9-1	12F2 (62.17 cM)	REV	641178	NC_000078.6	113736113..113736406	-1	MGI:4439810	Ighv5-9-1
IGHV2-6	12F2 (62.17 cM)	REV	630486	NC_000078.6	113716672..113716962	-1	MGI:4439518	Ighv2-6
IGHV5-12	12F2 (62.16 cM)	REV	668395	NC_000078.6	113702126..113702419	-1	MGI:4439516	Ighv5-12
IGHV5-11	12F2 (62.16 cM)	REV	777784	NC_000078.6	113687229..113687505	-1	MGI:5009891	Ighv5-11
IGHV2-5	12F2 (62.16 cM)	REV	638605	NC_000078.6	113685482..113685774	-1	MGI:4439517	Ighv2-5
IGHV5-10	12F2 (62.16 cM)	REV	777783	NC_000078.6	113669673..113669968	-1	MGI:3642589	Ighv5-10
IGHV5-9	12F2 (62.15 cM)	REV	544896	NC_000078.6	113661771..113662228	-1	MGI:4439873	Ighv5-9
IGHV5-8	12F2 (62.15 cM)	REV	777782	NC_000078.6	113654967..113655245	-1	MGI:5009890	Ighv5-8
IGHV2-4	12F2 (62.15 cM)	REV	668389	NC_000078.6	113653291..113653583	-1	MGI:3643263	Ighv2-4
IGHV5-7	12F2 (62.14 cM)	REV	777781	NC_000078.6	113634686..113634981	-1	MGI:3642590	Ighv5-7
IGHV5-6	12F2 (62.14 cM)	REV	777780	NC_000078.6	113625508..113625801	-1	MGI:4439815	Ighv5-6

IGHV5-5	12F2 (62.14 cM)	REV	777779	NC_000078.6	113612965..113613442	-1	MGI:5009889	Ighv5-5
IGHV2-3	12F2 (62.14 cM)	REV	238412	NC_000078.6	113611184..113611476	-1	MGI:4439872	Ighv2-3
IGHV6-1	12F2 (62.14 cM)	REV	777689	NC_000078.6	113603460..113603928	-1	MGI:5009888	Ighv6-1
IGHV5-4	12F2 (62.13 cM)	REV	777688	NC_000078.6	113597448..113597741	-1	MGI:4439895	Ighv5-4
IGHV5-3	12F2 (62.13 cM)	REV	777687	NC_000078.6	113589967..113590243	-1	MGI:5009887	Ighv5-3
IGHV2-2	12F2 (62.13 cM)	REV	777686	NC_000078.6	113588267..113588700	-1	MGI:4439894	Ighv2-2
IGHV5-2	12F2 (62.13 cM)	REV	777685	NC_000078.6	113578504..113578990	-1	MGI:4439893	Ighv5-2
IGHV2-1	12F2 (62.13 cM)	REV	777684	NC_000078.6	113574247..113574540	-1	MGI:4936981	Ighv2-1
IGHV5-1	12F2 (62.13 cM)	REV	777683	NC_000078.6	113572929..113573222	-1	MGI:5009886	Ighv5-1
IGHD5-1	12F2 (62.11 cM)	REV	777682	NC_000078.6	113526800..113526809	-1	MGI:4937117	Ighd5-1
IGHD3-1	12F2 (62.11 cM)	REV	777681	NC_000078.6	113525313..113525329	-1	MGI:4439891	Ighd3-1
IGHD1-1	12F2 (62.10 cM)	REV	777657	NC_000078.6	113482170..113482192	-1	MGI:4439871	Ighd1-1
IGHD6-1	12F2 (62.10 cM)	REV	777680	NC_000078.6	113480143..113480171	-1	MGI:4937254	Ighd6-1
IGHD2-3	12F2 (62.10 cM)	REV	777679	NC_000078.6	113475400..113475416	-1	MGI:4439708	Ighd2-3
IGHD6-2	12F2 (62.10 cM)	REV	777678	NC_000078.6	113474875..113474903	-1	MGI:4937120	Ighd6-2
IGHD2-4	12F2 (62.10 cM)	REV	777677	NC_000078.6	113470694..113470710	-1	MGI:4439709	Ighd2-4
IGHD5-2	12F2 (62.10 cM)	REV	777676	NC_000078.6	113469426..113469435	-1	MGI:4936898	Ighd5-2
IGHD2-5	12F2 (62.10 cM)	REV	777675	NC_000078.6	113466027..113466043	-1	MGI:4439705	Ighd2-5
IGHD5-3	12F2 (62.10 cM)	REV	777674	NC_000078.6	113464761..113464770	-1	MGI:4937297	Ighd5-3
IGHD5-7	12F2 (62.10 cM)	REV	777673	NC_000078.6	113464524..113464552	-1	MGI:4936973	Ighd5-7
IGHD2-6	12F2 (62.10 cM)	REV	777672	NC_000078.6	113461369..113461385	-1	MGI:4439865	Ighd2-6
IGHD5-4	12F2 (62.10 cM)	REV	777670	NC_000078.6	113460101..113460110	-1	MGI:4937058	Ighd5-4
IGHD5-8	12F2 (62.10 cM)	REV	777669	NC_000078.6	113459864..113459892	-1	MGI:4937171	Ighd5-8
IGHD2-7	12F2 (62.10 cM)	REV	777667	NC_000078.6	113456720..113456736	-1	MGI:4439866	Ighd2-7
IGHD5-5	12F2 (62.10 cM)	REV	777665	NC_000078.6	113454942..113454951	-1	MGI:4937334	Ighd5-5
IGHD2-8	12F2 (62.10 cM)	REV	777664	NC_000078.6	113450851..113450867	-1	MGI:4439706	Ighd2-8
IGHD5-6	12F2 (62.10 cM)	REV	777663	NC_000078.6	113449588..113449597	-1	MGI:4937234	Ighd5-6
IGHD3-2	12F2 (62.10 cM)	REV	777662	NC_000078.6	113448214..113448229	-1	MGI:4439707	Ighd3-2
IGHD4-1	12F2 (62.10 cM)	REV	777661	NC_000078.6	113430528..113430538	-1	MGI:4439801	Ighd4-1
IGHJ1	12F2 (62.10 cM)	REV	777648	NC_000078.6	113429781..113429833	-1	MGI:4439802	Ighj1

IGHJ2	12F2 (62.10 cM)	REV	777654	NC_000078.6	113429468..113429515	-1	MGI:4439803	Ighj2
IGHJ3	12F2 (62.10 cM)	REV	777655	NC_000078.6	113429085..113429132	-1	MGI:4439767	Ighj3
IGHJ4	12F2 (62.10 cM)	REV	777656	NC_000078.6	113428514..113428567	-1	MGI:4439658	Ighj4
IGHM	12F2 (62.10 cM)	REV	16019	NC_000078.6	113418826..113422730	-1	MGI:96448	Ighm
IGHD	12F2 (62.10 cM)	REV	380797	NC_000078.6	113407535..113416324	-1	MGI:96447	Ighd
IGHG3	12F2 (62.10 cM)	REV	380795	NC_000078.6	113357442..113361232	-1	MGI:2144790	Ighg3
IGHG1	12F2 (62.10 cM)	REV	16017	NC_000078.6	113326544..113330523	-1	MGI:96446	Ighg1
IGHG2B	12F2 (62.10 cM)	REV	16016	NC_000078.6	113304314..113307933	-1	MGI:96445	Ighg2b
IGHG2C	12F2 (62.10 cM)	REV	404711	NC_000078.6	113287389..113288932	-1	MGI:2686979	Ighg2c
IGHE	12F2 (62.10 cM)	REV	380792	NC_000078.6	113269263..113273248	-1	MGI:2685746	Ighe
IGHA	12F2 (62.09 cM)	REV	238447	NC_000078.6	113256204..113260236	-1	MGI:96444	Igha

FIG. 22

IMGT							NCBI		
Gene	Loc.	Orient.	Locus	Position	Accession number	Positions	Gene positions on chromosome	Accession number	Gene positions in sequences
IGKC	2q11.2	REV	IGK		J00241	334..653	88937992..88938311	NT_022184.14	67900421..67900740
IGKJ5	2q11.2	REV	IGK	1714339..1714417	J00242	1536..1612	88941195..88941271	NT_022184.14	67903624..67903700
IGKJ4	2q11.2	REV	IGK	1714024..1714102	J00242	1221..1297	88941513..88941589	NT_022184.14	67903942..67904018
IGKJ3	2q11.2	REV	IGK	1713683..1713760	J00242	880..955	88941848..88941923	NT_022184.14	67904277..67904352
IGKJ2	2q11.2	REV	IGK	1713376..1713455	J00242	573..650	88942152..88942229	NT_022184.14	67904581..67904658
IGKJ1	2q11.2	REV	IGK	1713015..1713093	J00242	212..288	88942513..88942589	NT_022184.14	67904942..67905018
IGKV4-1	2q11.2	FWD	IGK	1688795..1689406	Z00023	98..709	88966203..88966814	NT_022184.14	67928632..67929243
IGKV5-2	2q11.2	FWD	IGK	1677164..1677682	X02485	304..822	88977926..88978445	NT_022184.14	67940355..67940874
IGKV7-3	2q11.2	REV	IGK	1659301..1659929	X12682	683..1281	88995711..88996309	NT_022184.14	67958140..67958738
IGKV2-4	2q11.2	REV	IGK	1642592..1643349	X72814	569..1296	89012284..89013011	NT_022184.14	67974713..67975440
IGKV1-5	2q11.2	REV	IGK	1627192..1627697	Z00001	297..802	89027904..89028409	NT_022184.14	67990333..67990838
IGKV1-6	2q11.2	REV	IGK	1608228..1608734	M64858	131..637	89046866..89047372	NT_022184.14	68009295..68009801
IGKV3-7	2q11.2	REV	IGK	1595982..1596528	X02725	134..680	89059072..89059618	NT_022184.14	68021501..68022047
IGKV1-8	2q11.2	REV	IGK	1582087..1582586	K02097	950..1427	89073041..89073518	NT_022184.14	68035470..68035947
IGKV1-9	2q11.2	REV	IGK	1564529..1565034	K02096	691..1168	89090592..89091069	NT_022184.14	68053021..68053498
IGKV2-10	2q11.2	REV	IGK	1554301..1555022	Z00012	121..814	89100604..89101297	NT_022184.14	68063033..68063726
IGKV3-11	2q11.2	REV	IGK	1547302..1547845	X01668	134..677	89107753..89108296	NT_022184.14	68070182..68070725
IGKV1-12	2q11.2	REV	IGK	1534288..1534792	V01577	1170..1674	89120806..89121310	NT_022184.14	68083235..68083739
IGKV1-13	2q11.2	REV	IGK	1528520..1529026	K02093	427..903	89126602..89127078	NT_022184.14	68089031..68089507
IGKV2-14	2q11.2	REV	IGK	1496203..1496996	X72810	191..956	89158630..89159395	NT_022184.14	68121059..68121824
IGKV3-15	2q11.2	REV	IGK	1489297..1489840	M23090	676..1219	89165758..89166301	NT_022184.14	68128187..68128730
IGKV1-16	2q11.2	REV	IGK	1474657..1475162	J00248	131..636	89180437..89180942	NT_022184.14	68142866..68143371
IGKV1-17	2q11.2	REV	IGK	1457171..1457676	X72808	397..902	89197918..89198423	NT_022184.14	68160347..68160852
IGKV2-18	2q11.2	REV	IGK	1445516..1446322	X63400	341..1117	89209304..89210080	NT_022184.14	68171733..68172509

IGKV2-19	2q11.2	REV	IGK	1439747..1440043	X12692	814..1080	89215579..89215845	NT_022184.14	68178008..68178274
IGKV3-20	2q11.2	REV	IGK	1431886..1432450	X12686	108..672	89223142..89223706	NT_022184.14	68185571..68186135
IGKV6-21	2q11.2	REV	IGK	1414698..1415279	X63399	507..1088	89240320..89240901	NT_022184.14	68202749..68203330
IGKV1-22	2q11.2	REV	IGK	1403796..1404293	X71885	2665..3132	89251344..89251811	NT_022184.14	68213773..68214240
IGKV2-23	2q11.2	REV	IGK	1401965..1403001	X71885	834..1549	89252927..89253642	NT_022184.14	68215356..68216071
IGKV2-24	2q11.2	REV	IGK	1397878..1398710	X12684	154..986	89256897..89257729	NT_022184.14	68219326..68220158
IGKV3-25	2q11.2	REV	IGK	1380742..1382545	X06583	636..2411	89273094..89274871	NT_022184.14	68235523..68237300
IGKV2-26	2q11.2	REV	IGK	1378180..1378960	X71884	505..1257	89276679..89277432	NT_022184.14	68239108..68239861
IGKV1-27	2q11.2	REV	IGK	1361116..1361620	X63398	323..827	89293993..89294497	NT_022184.14	68256422..68256926
IGKV2-28	2q11.2	REV	IGK	1352578..1353341	X63397	305..1068	89302264..89303027	NT_022184.14	68264693..68265456
IGKV2-29	2q11.2	REV	IGK	1340097..1340853	X63396	322..1078	89314751..89315507	NT_022184.14	68277180..68277936
IGKV2-30	2q11.2	REV	IGK	1329442..1330257	X63403	898..1713	89325349..89326164	NT_022184.14	68287778..68288593
IGKV3-31	2q11.2	REV	IGK	1322273..1322839	X71883	1839..2376	89332799..89333336	NT_022184.14	68295228..68295765
IGKV1-32	2q11.2	REV	IGK	1320994..1321488	X71883	560..1034	89334142..89334616	NT_022184.14	68296571..68297045
IGKV1-33	2q11.2	REV	IGK	1306433..1306937	M64856	131..635	89348843..89349347	NT_022184.14	68311272..68311776
IGKV3-34	2q11.2	REV	IGK	1299120..1299680	X71891	588..1120	89356128..89356660	NT_022184.14	68318557..68319089
IGKV1-35	2q11.2	REV	IGK	1287738..1288241	X71890	456..930	89367568..89368042	NT_022184.14	68329997..68330471
IGKV2-36	2q11.2	REV	IGK	1279452..1279685	X71889	144..377	89376096..89376329	NT_022184.14	68338525..68338758
IGKV1-37	2q11.2	REV	IGK	1277171..1277675	X59316	356..860	89378106..89378610	NT_022184.14	68340535..68341039
IGKV2-38	2q11.2	REV	IGK	1264765..1265034	X71888	580..819	89390775..89391014	NT_022184.14	68353204..68353443
IGKV1-39	2q11.2	REV	IGK	1254806..1255310	X59315	134..638	89400468..89400972	NT_022184.14	68362897..68363401
IGKV2-40	2q11.2	REV	IGK	1244063..1244826	X59314	889..1652	89411128..89411721	NT_022184.14	68373387..68373980
IGKV2D-36	2q11.2	FWD	IGK	387386..387619	X71893	2718..2951	89562873..89563106	NT_032994.5	1322..1555
IGKV1D-35	2q11.2	FWD	IGK	378827..379330	X71894	121..595	89571166..89571640	NT_032994.5	9615..10089
IGKV3D-34	2q11.2	FWD	IGK	367325..367885	X71895	588..1120	89582610..89583142	NT_032994.5	21059..21591
IGKV1D-33	2q11.2	FWD	IGK	360069..360573	M64855	131..635	89589921..89590425	NT_032994.5	28370..28874
IGKV1D-32	2q11.2	FWD	IGK	345540..346034	X71896	578..1052	89604539..89605013	NT_032994.5	42988..43462
IGKV3D-31	2q11.2	FWD	IGK	344188..344755	X71896	1857..2394	89605819..89606356	NT_032994.5	44268..44805
IGKV2D-30	2q11.2	FWD	IGK	336744..337559	X63402	507..1322	89613009..89613824	NT_032994.5	51458..52273
IGKV2D-29	2q11.2	FWD	IGK	326154..326911	M31952	324..1081	89623657..89624414	NT_032994.5	62106..62863

IGKV2D-28	2q11.2	FWD	IGK	313676..314439	X12691	304..1067	89636130..89636893	NT_032994.5	74579..75342
IGKV1D-27	2q11.2	FWD	IGK	305082..305587	Z00004	525..1030	89644980..89645485	NT_032994.5	83429..83934
IGKV2D-26	2q11.2	FWD	IGK	287726..288491	AP001216	30326..31106	89662063..89662843	NT_032994.5	100512..101292
IGKV3D-25	2q11.2	FWD	IGK	284165..285949	X71886	628..2412	89664611..89666397	NT_032994.5	103060..104846
IGKV2D-24	2q11.2	FWD	IGK	268793..269625	X63401	185..1017	89680942..89681774	NT_032994.5	119391..120223
IGKV2D-23	2q11.2	FWD	IGK	264526..265540	X71887	834..1839	89685026..89686031	NT_032994.5	123475..124480
IGKV1D-22	2q11.2	FWD	IGK	263213..263710	X71887	2664..3131	89686856..89687323	NT_032994.5	125305..125772
IGKV6D-21	2q11.2	FWD	IGK	252235..252816	X12683	378..959	89697749..89698330	NT_032994.5	136198..136779
IGKV3D-20	2q11.2	FWD	IGK	234918..235482	X12687	108..672	89715082..89715646	NT_032994.5	153531..154095
IGKV2D-19	2q11.2	FWD	IGK	227325..227621	X71882	433..699	89722943..89723209	NT_032994.5	161392..161658
IGKV2D-18	2q11.2	FWD	IGK	221028..221834	X63395	308..1084	89728733..89729509	NT_032994.5	167182..167958
IGKV6D-41	2q11.2	FWD	IGK	204147..204727	M27751	220..772	89745835..89746387	NT_032994.5	184284..184836
IGKV1D-17	2q11.2	FWD	IGK	191094..191599	X63392	986..1491	89758963..89759468	NT_032994.5	197412..197917
IGKV1D-16	2q11.2	FWD	IGK	173645..174150	K01323	131..636	89776410..89776915	NT_032994.5	214859..215364
IGKV3D-15	2q11.2	FWD	IGK	158967..159510	X72815	71..614	89791050..89791593	NT_032994.5	229499..230042
IGKV2D-14	2q11.2	FWD	IGK	151823..152616	X72811	221..986	89797944..89798709	NT_032994.5	236393..237158
IGKV1D-13	2q11.2	FWD	IGK	119800..120306	X17262	130..636	89830253..89830759	NT_032994.5	268702..269208
IGKV1D-12	2q11.2	FWD	IGK	114055..114538	X17263	131..607	89836021..89836497	NT_032994.5	274470..274946
IGKV3D-11	2q11.2	FWD	IGK	100971..101514	X17264	83..626	89849045..89849588	NT_032994.5	287494..288037
IGKV2D-10	2q11.2	FWD	IGK	93730..94523	X17265	122..887	89856036..89856801	NT_032994.5	294485..295250
IGKV1D-42	2q11.2	FWD	IGK	83687..84183	X72816	209..705	89866370..89866866	NT_032994.5	304819..305315
IGKV1D-43	2q11.2	FWD	IGK	63823..64328	X72817	150..655	89886225..89886730	NT_032994.5	324674..325179
IGKV1D-8	2q11.2	FWD	IGK	52970..53474	Z00008	305..781	89897079..89897555	NT_032994.5	335528..336004
IGKV3D-7	2q11.2	FWD	IGK	39007..39568	X72820	441..1002	89911009..89911570	NT_032994.5	349458..350019

FIG. 23

IMGT Gene	Chromosomal localization	Orientation	NCBI Gene ID	Reference GRCm38.p3 C57BL/6J	NCBI Gene positions in sequence	Orientation sequence	MGI ID	MGI symbol
IGKV2-137	6C1 (30.89 cM)	FWD	692187	NC_000072.6	67555636..67556216	1	MGI:4439879	Igkv2-137
IGKV1-136	6C1 (30.90 cM)	FWD	692186	NC_000072.6	67593876..67594308	1	MGI:4947614	Igkv1-136
IGKV1-135	6C1 (30.91 cM)	FWD	243420	NC_000072.6	67609745..67610508	1	MGI:3819952	Igkv1-135
IGKV14-134-1	6C1 (30.94 cM)	REV	692185	NC_000072.6	67711174..67711628	-1	MGI:5009883	Igkv14-134-1
IGKV17-134	6C1 (30.94 cM)	REV	692184	NC_000072.6	67720729..67721225	-1	MGI:4936953	Igkv17-134
IGKV1-133	6C1 (30.95 cM)	FWD	628027	NC_000072.6	67724914..67725661	1	MGI:3648380	Igkv1-133
IGKV1-132	6C1 (30.96 cM)	FWD	243423	NC_000072.6	67759700..67760413	1	MGI:3648800	Igkv1-132
IGKV1-131	6C1 (30.96 cM)	REV	628056	NC_000072.6	67766036..67766772	-1	MGI:3645551	Igkv1-131
IGKV14-130	6C1 (30.97 cM)	FWD	628072	NC_000072.6	67791046..67791511	1	MGI:3645770	Igkv14-130
IGKV9-129	6C1 (30.98 cM)	FWD	692182	NC_000072.6	67839793..67840266	1	MGI:3525017	Igkv9-129
IGKV9-128	6C1 (30.99 cM)	FWD	692181	NC_000072.6	67847409..67847874	1	MGI:3809196	Igkv9-128
IGKV17-127	6C1 (30.99 cM)	FWD	243433	NC_000072.6	67861159..67861659	1	MGI:3646891	Igkv17-127
IGKV14-126-1	6C1 (30.99 cM)	FWD	692180	NC_000072.6	67876011..67876477	1	MGI:5009882	Igkv14-126-1
IGKV14-126	6C1 (31.00 cM)	FWD	628127	NC_000072.6	67896177..67896642	1	MGI:3643131	Igkv14-126
IGKV11-125	6C1 (31.01 cM)	FWD	243428	NC_000072.6	67913573..67914052	1	MGI:3642338	Igkv11-125
IGKV9-124	6C1 (31.02 cM)	REV	243431	NC_000072.6	67942076..67942540	-1	MGI:3646892	Igkv9-124
IGKV9-123	6C1 (31.02 cM)	REV	628144	NC_000072.6	67954230..67954690	-1	MGI:3643848	Igkv9-123
IGKV1-122	6C1 (31.04 cM)	FWD	434024	NC_000072.6	68016742..68017488	1	MGI:4439722	Igkv1-122
IGKV17-121	6C1 (31.05 cM)	FWD	667435	NC_000072.6	68036818..68037318	1	MGI:3647671	Igkv17-121
IGKV9-120	6C1 (31.05 cM)	FWD	434025	NC_000072.6	68049983..68050454	1	MGI:3647784	Igkv9-120
IGKV9-119	6C1 (31.05 cM)	FWD	692177	NC_000072.6	68056345..68056810	1	MGI:5009881	Igkv9-119
IGKV14-118-2	6C1 (31.06 cM)	FWD	692176	NC_000072.6	68066369..68066828	1	MGI:5009880	Igkv14-118-2
IGKV14-118-1	6C1 (31.06 cM)	FWD	692175	NC_000072.6	68082547..68083145	1	MGI:5009879	Igkv14-118-1
IGKV11-118	6C1 (31.07 cM)	FWD	692174	NC_000072.6	68105414..68105880	1	MGI:5009878	Igkv11-118

IGKV1-117	6C1 (31.06 cM)	FWD	16098	NC_000072.6	68121091..68121825	1	MGI:4439721	Igkv1-117
IGKV1-115	6C1 (31.09 cM)	FWD	628206	NC_000072.6	68160797..68161716	1	MGI:3644873	Igkv1-115
IGKV11-114	6C1 (31.09 cM)	FWD	692173	NC_000072.6	68164459..68164923	1	MGI:5009877	Igkv11-114
IGKV2-113	6C1 (31.09 cM)	FWD	692172	NC_000072.6	68178801..68179564	1	MGI:5009876	Igkv2-113
IGKV2-112	6C1 (31.11 cM)	FWD	381776	NC_000072.6	68219981..68220705	1	MGI:3644894	Igkv2-112
IGKV14-111	6C1 (31.12 cM)	FWD	545847	NC_000072.6	68256404..68256869	1	MGI:4439863	Igkv14-111
IGKV1-110	6C1 (31.12 cM)	FWD	381777	NC_000072.6	68270527..68271265	1	MGI:4439558	Igkv1-110
IGKV2-109	6C1 (31.13 cM)	FWD	628268	NC_000072.6	68302439..68303158	1	MGI:3642626	Igkv2-109
IGKV1-108	6C1 (31.13 cM)	FWD	628272	NC_000072.6	68312054..68312359	1	MGI:3644576	Igkv1-108
IGKV2-107	6C1 (31.14 cM)	FWD	628283	NC_000072.6	68326098..68326752	1	MGI:3645630	Igkv2-107
IGKV11-106	6C1 (31.14 cM)	FWD	628293	NC_000072.6	68339527..68339995	1	MGI:3648899	Igkv11-106
IGKV2-105	6C1 (31.15 cM)	FWD	692170	NC_000072.6	68348661..68349441	1	MGI:5009874	Igkv2-105
IGKV16-104	6C1 (31.17 cM)	FWD	381778	NC_000072.6	68425605..68426072	1	MGI:2685913	Igkv16-104
IGKV15-103	6C1 (31.18 cM)	FWD	692169	NC_000072.6	68437468..68437925	1	MGI:96513	Igkv15-103
IGKV15-102	6C1 (31.18 cM)	REV	692171	NC_000072.6	68466126..68466590	-1	MGI:5009875	Igkv15-102
IGKV20-101-2	6C1 (31.19 cM)	FWD	724035	NC_000072.6	68474888..68475098	1	MGI:5009884	Igkv20-101-2
IGKV15-101-1	6C1 (31.19 cM)	FWD	692167	NC_000072.6	68479082..68479573	1	MGI:5009872	Igkv15-101-1
IGKV15-101	6C1 (31.19 cM)	REV	692168	NC_000072.6	68481421..68481718	-1	MGI:5009873	Igkv15-101
IGKV14-100	6C1 (31.20 cM)	FWD	243439	NC_000072.6	68519012..68519477	1	MGI:4439559	Igkv14-100
IGKV1-99	6C1 (31.21 cM)	FWD	434028	NC_000072.6	68541658..68542422	1	MGI:4439724	Igkv1-99
IGKV12-98	6C1 (31.22 cM)	FWD	435900	NC_000072.6	68570763..68571235	1	MGI:4439560	Igkv12-98
IGKV15-97	6C1 (31.22 cM)	FWD	692166	NC_000072.6	68591380..68591832	1	MGI:5009871	Igkv15-97
IGKV10-96	6C1 (31.24 cM)	REV	692165	NC_000072.6	68631965..68632430	-1	MGI:4439561	Igkv10-96
IGKV2-95-2	6C1 (31.24 cM)	REV	692164	NC_000072.6	68647999..68648531	-1	MGI:4937167	Igkv2-95-2
IGKV2-95-1	6C1 (31.25 cM)	FWD	692163	NC_000072.6	68670752..68671335	1	MGI:5009870	Igkv2-95-1
IGKV10-95	6C1 (31.25 cM)	FWD	434031	NC_000072.6	68680379..68680848	1	MGI:3644598	Igkv10-95
IGKV10-94	6C1 (31.26 cM)	REV	667550	NC_000072.6	68704508..68704978	-1	MGI:3646140	Igkv10-94
IGKV2-93-1	6C1 (31.26 cM)	REV	692162	NC_000072.6	68712925..68713508	-1	MGI:5009869	Igkv2-93-1
IGKV19-93	6C1 (31.27 cM)	REV	692161	NC_000072.6	68736297..68736764	-1	MGI:107617	Igkv19-93
IGKV4-92	6C1 (31.28 cM)	REV	384410	NC_000072.6	68755038..68755593	-1	MGI:2686254	Igkv4-92

IGKV4-91	6C1 (31.28 cM)	REV	434033	NC_000072.6	68768555..68769103	-1	MGI:3642277	Igkv4-91
IGKV4-90	6C1 (31.29 cM)	REV	434034	NC_000072.6	68807180..68807708	-1	MGI:4439830	Igkv4-90
IGKV13-89-1	6C1 (31.29 cM)	FWD	692155	NC_000072.6	68810495..68810543	1	MGI:5009868	Igkv13-89-1
IGKV12-89	6C1 (31.29 cM)	REV	384411	NC_000072.6	68834846..68835307	-1	MGI:4439829	Igkv12-89
IGKV1-88	6C1 (31.31 cM)	REV	692154	NC_000072.6	68862265..68863031	-1	MGI:4439828	Igkv1-88
IGKV13-87	6C1 (31.32 cM)	FWD	692153	NC_000072.6	68902801..68903266	1	MGI:3779399	Igkv13-87
IGKV4-86	6C1 (31.33 cM)	REV	243451	NC_000072.6	68910411..68910938	-1	MGI:2685305	Igkv4-86
IGKV13-85	6C1 (31.33 cM)	REV	434036	NC_000072.6	68930269..68930734	-1	MGI:4439827	Igkv13-85
IGKV13-84	6C1 (31.34 cM)	FWD	692152	NC_000072.6	68939602..68940067	1	MGI:96514	Igkv13-84
IGKV4-83	6C1 (31.34 cM)	REV	692145	NC_000072.6	68961378..68962019	-1	MGI:5009867	Igkv4-83
IGKV13-82	6C1 (31.35 cM)	FWD	692144	NC_000072.6	68979198..68979663	1	MGI:5009866	Igkv13-82
IGKV4-81	6C1 (31.35 cM)	REV	243453	NC_000072.6	68990758..68991294	-1	MGI:2685306	Igkv4-81
IGKV13-80-1	6C1 (31.36 cM)	FWD	692143	NC_000072.6	69009143..69009513	1	MGI:5009865	Igkv13-80-1
IGKV4-80	6C1 (31.36 cM)	REV	545848	NC_000072.6	69016558..69017080	-1	MGI:4439653	Igkv4-80
IGKV4-79	6C1 (31.37 cM)	REV	213684	NC_000072.6	69042972..69043505	-1	MGI:2685040	Igkv4-79
IGKV13-78-1	6C1 (31.37 cM)	FWD	628498	NC_000072.6	69051444..69051794	1	MGI:3647961	Igkv13-78-1
IGKV4-78	6C1 (31.38 cM)	REV	545849	NC_000072.6	69059690..69060224	-1	MGI:3819775	Igkv4-78
IGKV4-77	6C1 (31.39 cM)	REV	667621	NC_000072.6	69110904..69111432	-1	MGI:3647937	Igkv4-77
IGKV13-76	6C1 (31.40 cM)	FWD	692142	NC_000072.6	69137866..69138332	1	MGI:5009864	Igkv13-76
IGKV4-75	6C1 (31.41 cM)	REV	692141	NC_000072.6	69156118..69156659	-1	MGI:5009863	Igkv4-75
IGKV13 74 1	6C1 (31.41 cM)	FWD	692140	NC_000072.6	69177416..69177787	1	MGI:5009862	Igkv13 74-1
IGKV4-74	6C1 (31.42 cM)	REV	236047	NC_000072.6	69184826..69185361	-1	MGI:3779447	Igkv4-74
IGKV13-73-1	6C1 (31.42 cM)	FWD	692139	NC_000072.6	69190073..69190282	1	MGI:5009861	Igkv13-73-1
IGKV4-73	6C1 (31.42 cM)	REV	628516	NC_000072.6	69197583..69198116	-1	MGI:3645825	Igkv4-73
IGKV4-72	6C1 (31.43 cM)	REV	385109	NC_000072.6	69226854..69227383	-1	MGI:2686345	Igkv4-72
IGKV13-71-1	6C1 (31.43 cM)	FWD	692138	NC_000072.6	69235927..69236158	1	MGI:5009860	Igkv13-71-1
IGKV4-71	6C1 (31.43 cM)	REV	434586	NC_000072.6	69243160..69243688	-1	MGI:4439654	Igkv4-71
IGKV4-70	6C1 (31.44 cM)	REV	385120	NC_000072.6	69267888..69268412	-1	MGI:2686348	Igkv4-70
IGKV4-69	6C1 (31.45 cM)	REV	628541	NC_000072.6	69283794..69284319	-1	MGI:3648668	Igkv4-69
IGKV4-68	6C1 (31.45 cM)	REV	384515	NC_000072.6	69304834..69305363	-1	MGI:2686265	Igkv4-68

IGKV12-67	6C1 (31.46 cM)	REV	628551	NC_000072.6	69324177..69324646	-1	MGI:3645399	Igkv12-67
IGKV12-66	6C1 (31.46 cM)	REV	692133	NC_000072.6	69334604..69335076	-1	MGI:5009859	Igkv12-66
IGKV4-65	6C1 (31.47 cM)	REV	667670	NC_000072.6	69342472..69343004	-1	MGI:3644339	Igkv4-65
IGKV13-64	6C1 (31.47 cM)	FWD	628564	NC_000072.6	69362722..69363187	1	MGI:5009834	Igkv13-64
IGKV4-63	6C1 (31.48 cM)	REV	628571	NC_000072.6	69377944..69378472	-1	MGI:3645235	Igkv4-63
IGKV13-62-1	6C1 (31.48 cM)	FWD	692119	NC_000072.6	69392439..69392815	1	MGI:5009858	Igkv13-62-1
IGKV4-62	6C1 (31.48 cM)	REV	636752	NC_000072.6	69399812..69400344	-1	MGI:3643587	Igkv4-62
IGKV13-61-1	6C1 (31.49 cM)	FWD	692118	NC_000072.6	69409499..69409875	1	MGI:5009857	Igkv13-61-1
IGKV4-61	6C1 (31.49 cM)	REV	546244	NC_000072.6	69416893..69417425	-1	MGI:4439819	Igkv4-61
IGKV4-59	6C1 (31.50 cM)	REV	667683	NC_000072.6	69438218..69438741	-1	MGI:3646808	Igkv4-59
IGKV4-60	6C1 (31.51 cM)	REV	385277	NC_000072.6	69463288..69463725	-1	MGI:3708737	Igkv4-60
IGKV4-58	6C1 (31.52 cM)	REV	381831	NC_000072.6	69500254..69500758	-1	MGI:2685923	Igkv4-58
IGKV13-57-2	6C1 (31.52 cM)	FWD	724106	NC_000072.6	69523739..69524016	1	MGI:5009885	Igkv13-57-2
IGKV4-57-1	6C1 (31.53 cM)	REV	384514	NC_000072.6	69544368..69544892	-1	MGI:2686264	Igkv4-57-1
IGKV13-57-1	6C1 (31.54 cM)	FWD	692114	NC_000072.6	69569737..69570109	1	MGI:5009856	Igkv13-57-1
IGKV4-57	6C1 (31.54 cM)	REV	235952	NC_000072.6	69575975..69576500	-1	MGI:2685035	Igkv4-57
IGKV13-56-1	6C1 (31.54 cM)	FWD	692113	NC_000072.6	69581244..69581452	1	MGI:5009855	Igkv13-56-1
IGKV4-56	6C1 (31.54 cM)	REV	619743	NC_000072.6	69587295..69587810	-1	MGI:4439916	Igkv4-56
IGKV13-55-1	6C1 (31.55 cM)	FWD	692112	NC_000072.6	69599886..69600262	1	MGI:5009854	Igkv13-55-1
IGKV4-55	6C1 (31.55 cM)	REV	385253	NC_000072.6	69607275..69607801	-1	MGI:2686370	Igkv4-55
IGKV13-54-1	6C1 (31.55 cM)	FWD	692105	NC_000072.6	69617048..69617423	1	MGI:5009853	Igkv13-54-1
IGKV4-54	6C1 (31.56 cM)	REV	385291	NC_000072.6	69631648..69632178	-1	MGI:5009821	Igkv4-54
IGKV4-53	6C1 (31.56 cM)	REV	546213	NC_000072.6	69648824..69649354	-1	MGI:2686266	Igkv4-53
IGKV4-51	6C1 (31.58 cM)	REV	619806	NC_000072.6	69681406..69681939	-1	MGI:5009829	Igkv4-51
IGKV4-50	6C1 (31.58 cM)	REV	381782	NC_000072.6	69700767..69701287	-1	MGI:2685915	Igkv4-50
IGKV12-49	6C1 (31.59 cM)	REV	619824	NC_000072.6	69716498..69716956	-1	MGI:5009830	Igkv12-49
IGKV5-48	6C1 (31.59 cM)	REV	619846	NC_000072.6	69726573..69727125	-1	MGI:3642817	Igkv5-48
IGKV12-47	6C1 (31.60 cM)	REV	434037	NC_000072.6	69750854..69751310	-1	MGI:3644595	Igkv12-47
IGKV12-46	6C1 (31.61 cM)	REV	692245	NC_000072.6	69764523..69764992	-1	MGI:4439773	Igkv12-46
IGKV5-45	6C1 (31.61 cM)	REV	545850	NC_000072.6	69775750..69776306	-1	MGI:4439774	Igkv5-45

IGKV12-44	6C1 (31.63 cM)	REV	545851	NC_000072.6	69814631..69815100	-1	MGI:4439775	Igkv12-44
IGKV5-43	6C1 (31.63 cM)	REV	381783	NC_000072.6	69823355..69823911	-1	MGI:4943320	Igkv5-43
IGKV12-42	6C1 (31.64 cM)	REV	677861	NC_000072.6	69834792..69835245	-1	MGI:5009852	Igkv12-42
IGKV12-41	6C1 (31.65 cM)	REV	619960	NC_000072.6	69858420..69858884	-1	MGI:4439772	Igkv12-41
IGKV5-40-1	6C1 (31.65 cM)	REV	619974	NC_000072.6	69868595..69869193	-1	MGI:5009831	Igkv5-40-1
IGKV12-40	6C1 (31.66 cM)	REV	435904	NC_000072.6	69879350..69879819	-1	MGI:3643951	Igkv12-40
IGKV5-39	6C1 (31.67 cM)	REV	620017	NC_000072.6	69900424..69900977	-1	MGI:2686255	Igkv5-39
IGKV12-38	6C1 (31.69 cM)	REV	620050	NC_000072.6	69943186..69943648	-1	MGI:4439614	Igkv12-38
IGKV5-37	6C1 (31.69 cM)	REV	384417	NC_000072.6	69963312..69963861	-1	MGI:2686256	Igkv5-37
IGKV18-36	6C1 (31.71 cM)	REV	620088	NC_000072.6	69992465..69992977	-1	MGI:4439613	Igkv18-36
IGKV1-35	6C1 (31.72 cM)	REV	620105	NC_000072.6	70010949..70011673	-1	MGI:4439612	Igkv1-35
IGKV8-34	6C1 (31.73 cM)	REV	620126	NC_000072.6	70044112..70044678	-1	MGI:4949914	Igkv8-34
IGKV7-33	6C1 (31.74 cM)	REV	243461	NC_000072.6	70058632..70059199	-1	MGI:3577282	Igkv7-33
IGKV6-32	6C1 (31.74 cM)	REV	434039	NC_000072.6	70074024..70074584	-1	MGI:3641634	Igkv6-32
IGKV8-31	6C1 (31.76 cM)	REV	546905	NC_000072.6	70105860..70106179	-1	MGI:3644798	Igkv8-31
IGKV8-30	6C1 (31.76 cM)	REV	384419	NC_000072.6	70117061..70117617	-1	MGI:3642250	Igkv8-30
IGKV6-29	6C1 (31.77 cM)	REV	620191	NC_000072.6	70138462..70139082	-1	MGI:4439616	Igkv6-29
IGKV8-28	6C1 (31.78 cM)	REV	434040	NC_000072.6	70143593..70144161	-1	MGI:3642251	Igkv8-28
IGKV8-27	6C1 (31.79 cM)	REV	434041	NC_000072.6	70171809..70172270	-1	MGI:4439868	Igkv8-27
IGKV8-26	6C1 (31.80 cM)	FWD	620240	NC_000072.6	70193228..70193797	1	MGI:4439869	Igkv8-26
IGKV6-25	6C1 (31.81 cM)	FWD	381784	NC_000072.6	70215433..70215957	1	MGI:4439867	Igkv6-25
IGKV8-24	6C1 (31.81 cM)	REV	677858	NC_000072.6	70216858..70217421	-1	MGI:4947958	Igkv8-24
IGKV8-23-1	6C1 (31.82 cM)	FWD	434685	NC_000072.6	70240427..70240710	1	MGI:4947960	Igkv8-23-1
IGKV6-23	6C1 (31.83 cM)	REV	637227	NC_000072.6	70260409..70260933	-1	MGI:3711980	Igkv6-23
IGKV8-22	6C1 (31.85 cM)	REV	620387	NC_000072.6	70297554..70298119	-1	MGI:5009833	Igkv8-22
IGKV8-21	6C1 (31.85 cM)	REV	620400	NC_000072.6	70314895..70315452	-1	MGI:1330840	Igkv8-21
IGKV6-20	6C1 (31.86 cM)	REV	108024	NC_000072.6	70335841..70336479	-1	MGI:1330836	Igkv6-20
IGKV8-19	6C1 (31.87 cM)	REV	232065	NC_000072.6	70340876..70341448	-1	MGI:1330844	Igkv8-19
IGKV8-18	6C1 (31.87 cM)	FWD	667859	NC_000072.6	70355877..70356445	1	MGI:1330845	Igkv8-18
IGKV6-17	6C1 (31.88 cM)	FWD	667865	NC_000072.6	70371469..70371993	1	MGI:1330833	Igkv6-17

IGKV8-16	6C1 (31.89 cM)	REV	640340	NC_000072.6	70386672..70387238	-1	MGI:1330843	Igkv8-16
IGKV6-15	6C1 (31.89 cM)	REV	108022	NC_000072.6	70406469..70406992	-1	MGI:1330831	Igkv6-15
IGKV6-14	6C1 (31.91 cM)	REV	667881	NC_000072.6	70434952..70435476	-1	MGI:1330830	Igkv6-14
IGKV6-13	6C1 (31.92 cM)	REV	667899	NC_000072.6	70457503..70458036	-1	MGI:1330829	Igkv6-13
IGKV3-12-1	6C1 (31.94 cM)	REV	667908	NC_000072.6	70497662..70498342	-1	MGI:3645632	Igkv3-12-1
IGKV3-12	6C1 (31.95 cM)	FWD	667914	NC_000072.6	70518250..70518849	1	MGI:1330815	Igkv3-12
IGKV3-11	6C1 (31.96 cM)	FWD	667917	NC_000072.6	70553274..70554440	1	MGI:1330820	Igkv3-11
IGKV3-10	6C1 (31.97 cM)	FWD	667924	NC_000072.6	70572633..70573230	1	MGI:1330821	Igkv3-10
IGKV3-9	6C1 (31.98 cM)	FWD	667928	NC_000072.6	70588189..70588777	1	MGI:1330856	Igkv3-9
IGKV3-8	6C1 (31.98 cM)	FWD	108010	NC_000072.6	70588871..70589452	1	MGI:1330857	Igkv3-8
IGKV3-7	6C1 (31.99 cM)	FWD	108005	NC_000072.6	70607437..70608036	1	MGI:1330852	Igkv3-7
IGKV3-6	6C1 (32.00 cM)	FWD	667936	NC_000072.6	70642405..70643565	1	MGI:1330853	Igkv3-6
IGKV3-5	6C1 (32.01 cM)	FWD	667940	NC_000072.6	70663298..70663895	1	MGI:1330854	Igkv3-5
IGKV3-4	6C1 (32.01 cM)	FWD	626347	NC_000072.6	70671789..70672377	1	MGI:1330855	Igkv3-4
IGKV3-3	6C1 (32.02 cM)	FWD	667946	NC_000072.6	70686946..70687534	1	MGI:1330849	Igkv3-3
IGKV3-2	6C1 (32.03 cM)	FWD	626583	NC_000072.6	70698468..70699067	1	MGI:1330850	Igkv3-2
IGKV3-1	6C1 (32.03 cM)	FWD	108004	NC_000072.6	70703578..70704177	1	MGI:1330851	Igkv3-1
IGKJ1	6C1 (32.04 cM)	FWD	110759	NC_000072.6	70722562..70722599	1	MGI:1316689	Igkj1
IGKJ2	6C1 (32.04 cM)	FWD	110760	NC_000072.6	70722916..70722954	1	MGI:1316690	Igkj2
IGKJ3	6C1 (32.04 cM)	FWD	110761	NC_000072.6	70723223..70723260	1	MGI:1316691	Igkj3
IGKJ4	6C1 (32.04 cM)	FWD	110762	NC_000072.6	70723548..70723585	1	MGI:1316692	Igkj4
IGKJ5	6C1 (32.04 cM)	FWD	110763	NC_000072.6	70723886..70723923	1	MGI:1316738	Igkj5
IGKC	6C1 (32.04 cM)	FWD	16071	NC_000072.6	70726435..70726754	1	MGI:96495	Igkc

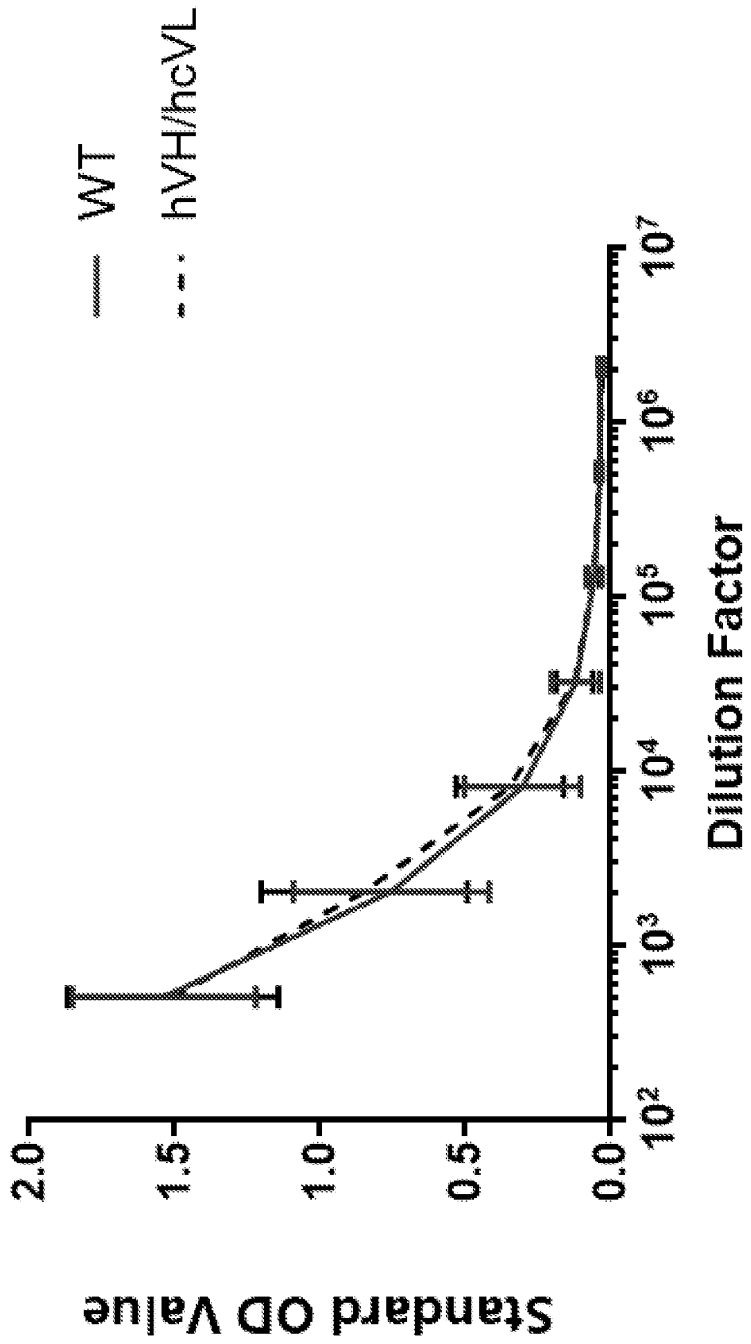

WT
hVH/hcVL
Standard OD Value
2.0
1.5
1.0
0.5
0.0
10^2
10^3
10^4
10^5
10^6
10^7
Dilution Factor

FIG. 24

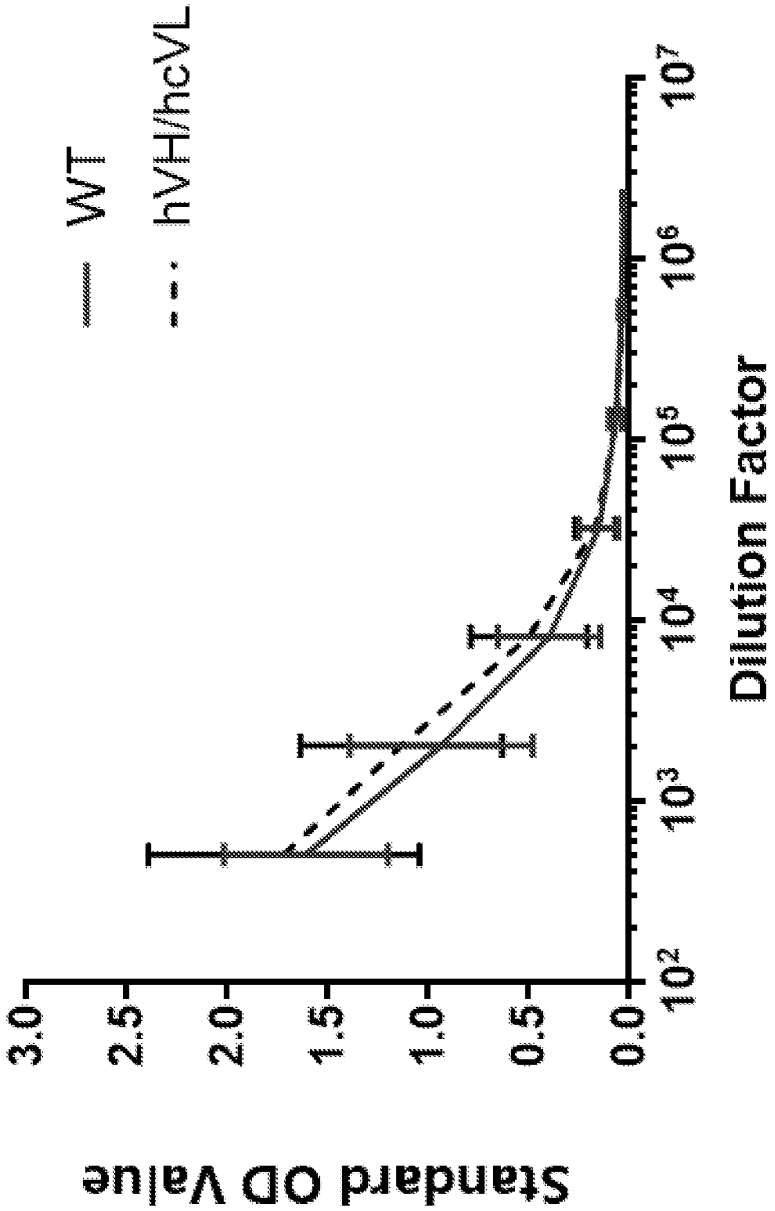

WT
hVH//hcVL
Standard OD Value
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10^2
10^3
10^4
10^5
10^6
10^7
Dilution Factor

FIG. 25

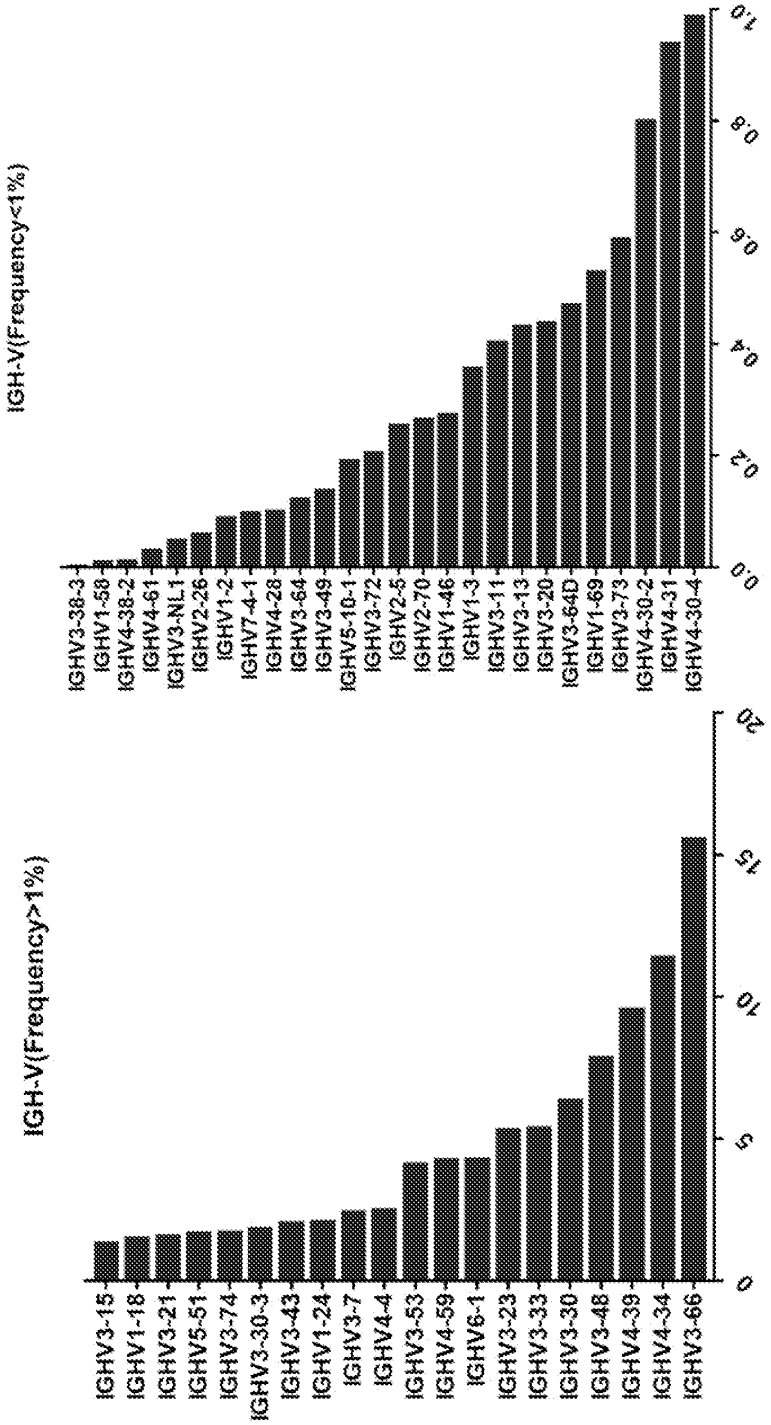


FIG. 26A

FIG. 26B

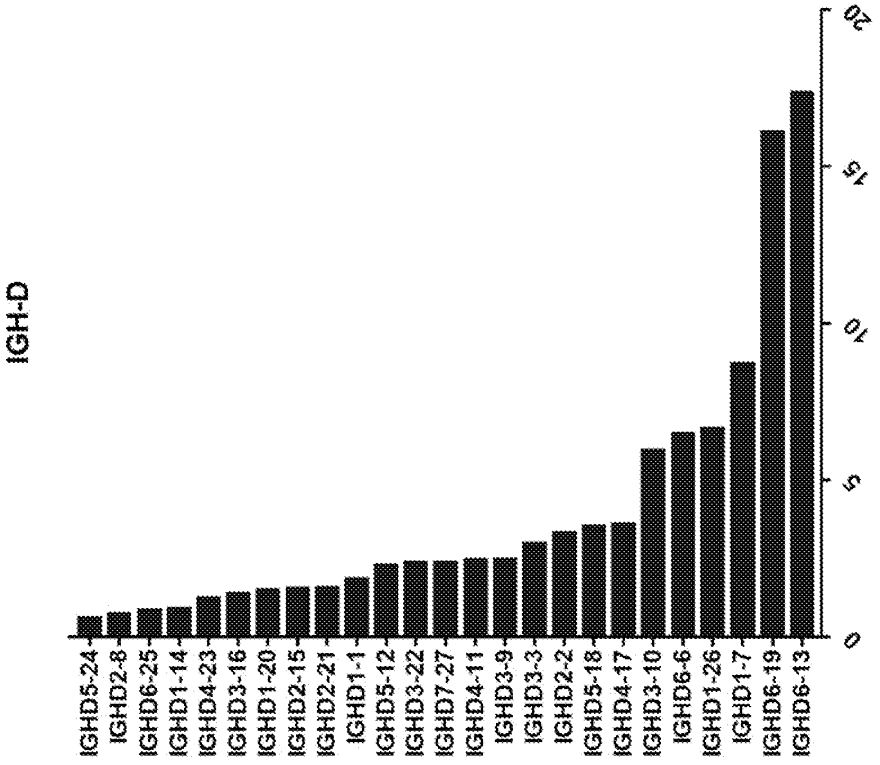

IGH-D
IGHD5-24
IGHD2-8
IGHD6-25
IGHD1-14
IGHD4-23
IGHD3-16
IGHD1-20
IGHD2-15
IGHD2-21
IGHD1-1
IGHD5-12
IGHD3-22
IGHD7-27
IGHD4-11
IGHD3-9
IGHD3-3
IGHD2-2
IGHD5-18
IGHD4-17
IGHD3-10
IGHD6-6
IGHD1-26
IGHD1-7
IGHD6-19
IGHD6-13
0
5
10
15
20

FIG. 26C

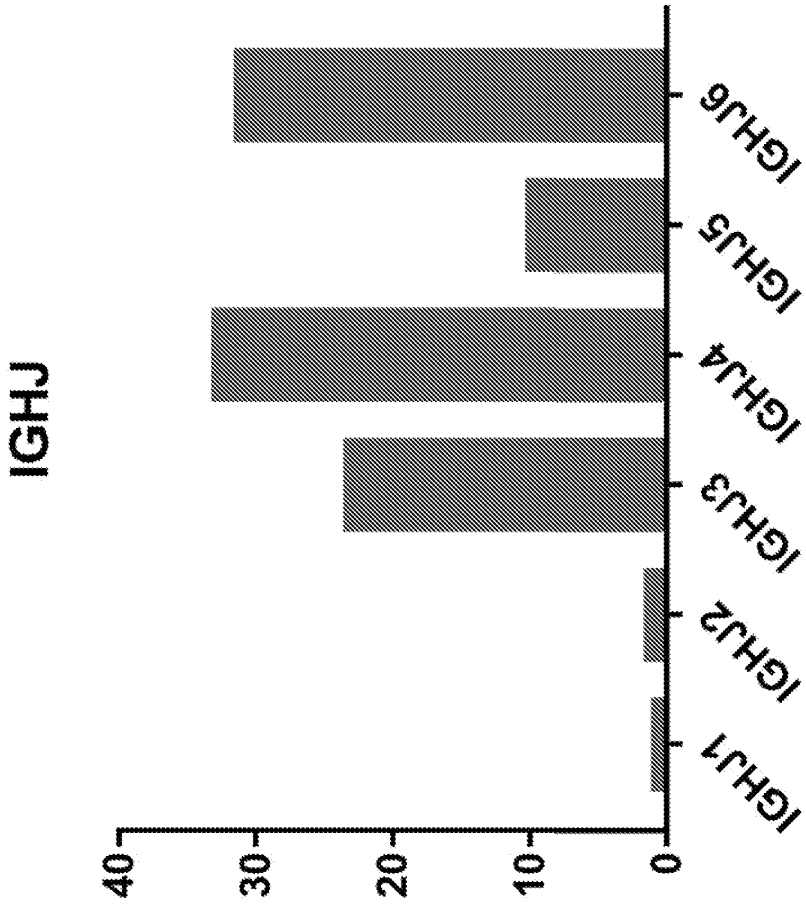


FIG. 26D

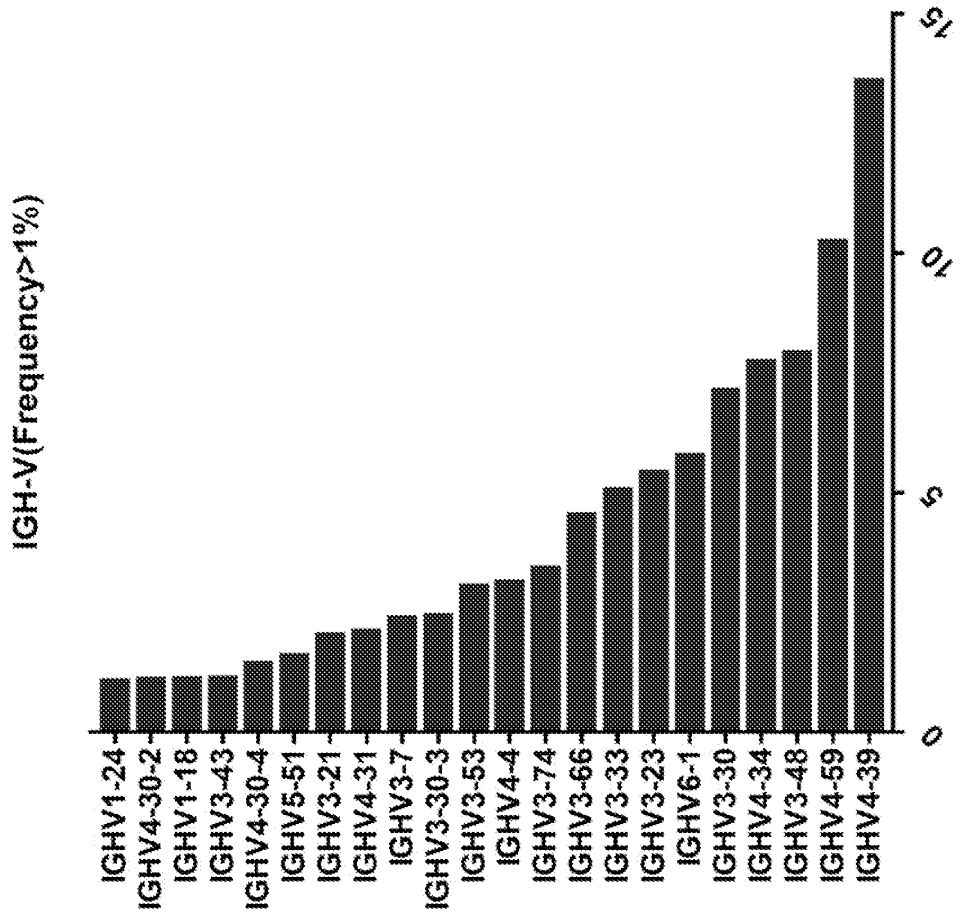

IGH-V(Frequency>1%)
IGHV1-24
IGHV4-30-2
IGHV1-18
IGHV3-43
IGHV4-30-4
IGHV5-51
IGHV3-21
IGHV4-31
IGHV3-7
IGHV3-30-3
IGHV3-53
IGHV4-4
IGHV3-74
IGHV3-66
IGHV3-33
IGHV3-23
IGHV6-1
IGHV3-30
IGHV4-34
IGHV3-48
IGHV4-59
IGHV4-39
0
5
10
15

FIG. 26E

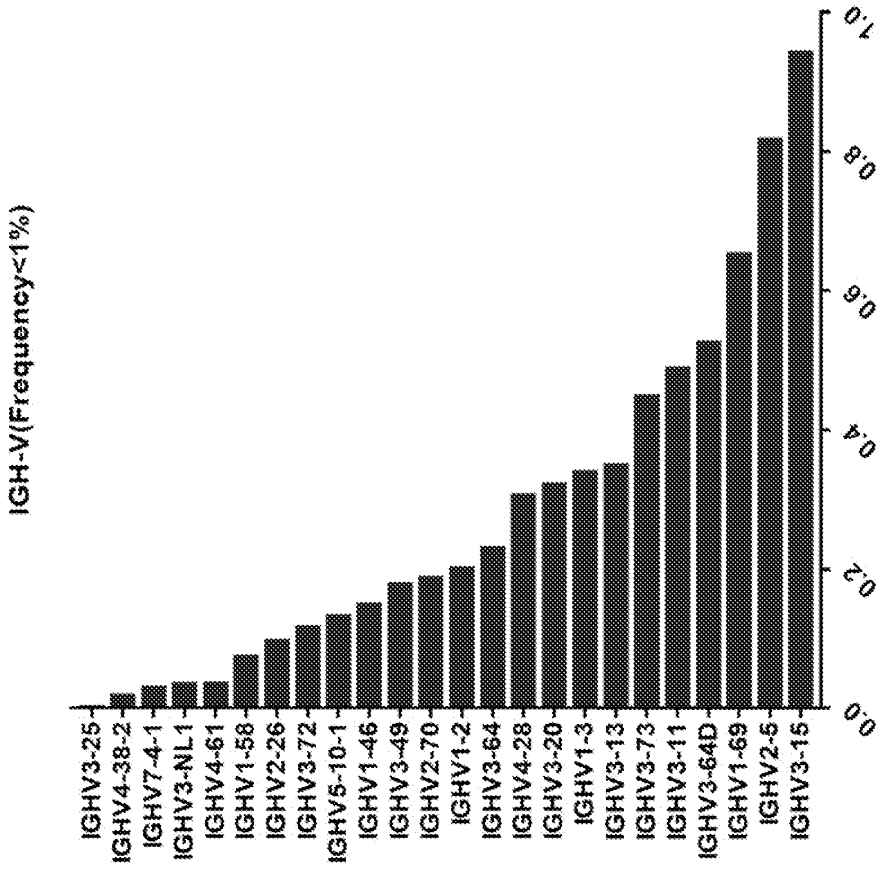

IGH-V(Frequency<1%)
IGHV3-25
IGHV4-38-2
IGHV7-4-1
IGHV3-NL1
IGHV4-61
IGHV1-58
IGHV2-26
IGHV3-72
IGHV5-10-1
IGHV1-46
IGHV3-49
IGHV2-70
IGHV1-2
IGHV3-64
IGHV4-28
IGHV3-20
IGHV1-3
IGHV3-13
IGHV3-73
IGHV3-11
IGHV3-64D
IGHV1-69
IGHV2-5
IGHV3-15
0.0
0.2
0.4
0.6
0.8
1.0

FIG. 26F

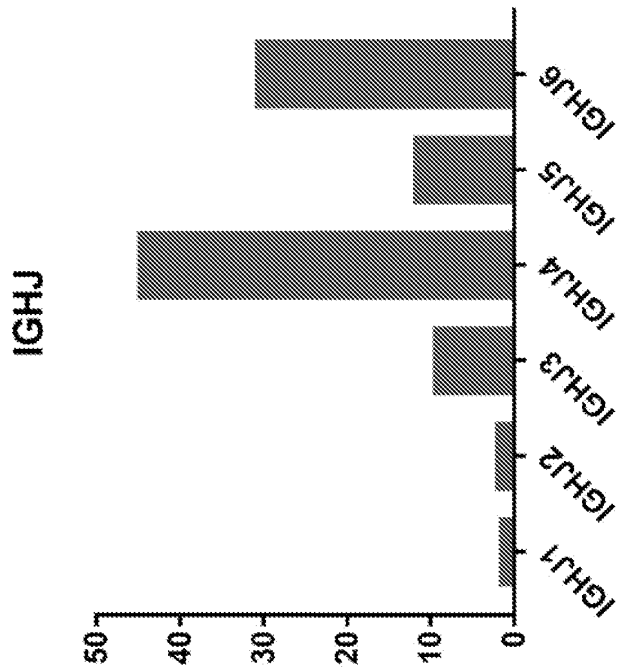


FIG. 26G

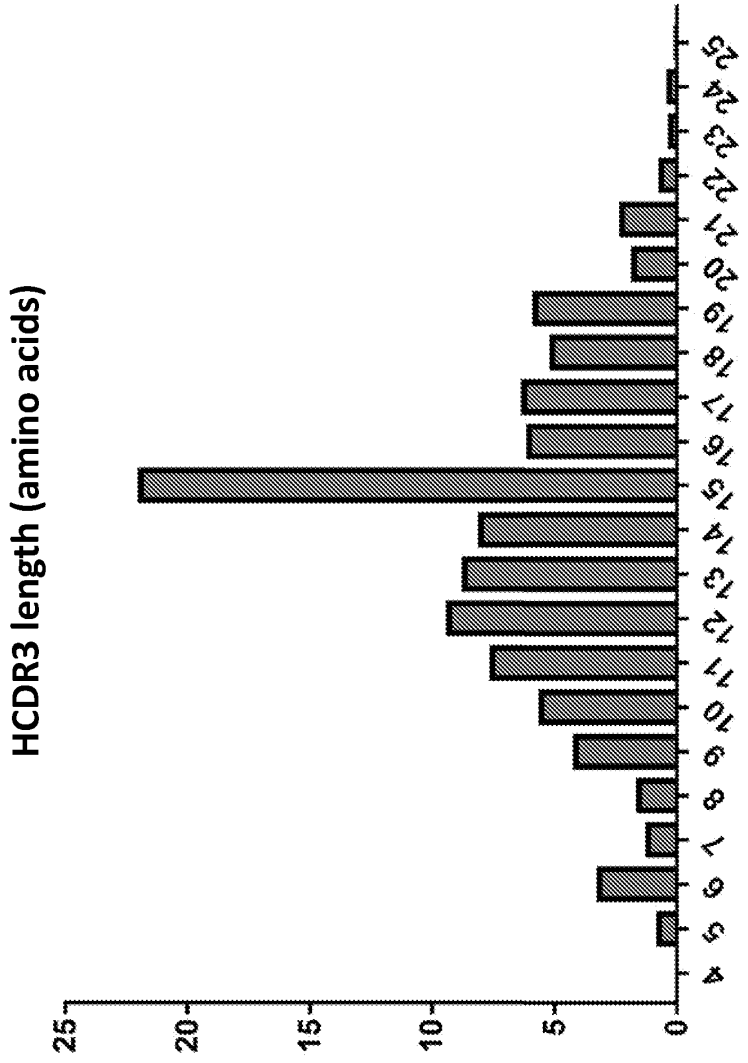

HCDR3 length (amino acids)
25
20
15
10
5
0
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

FIG. 27A

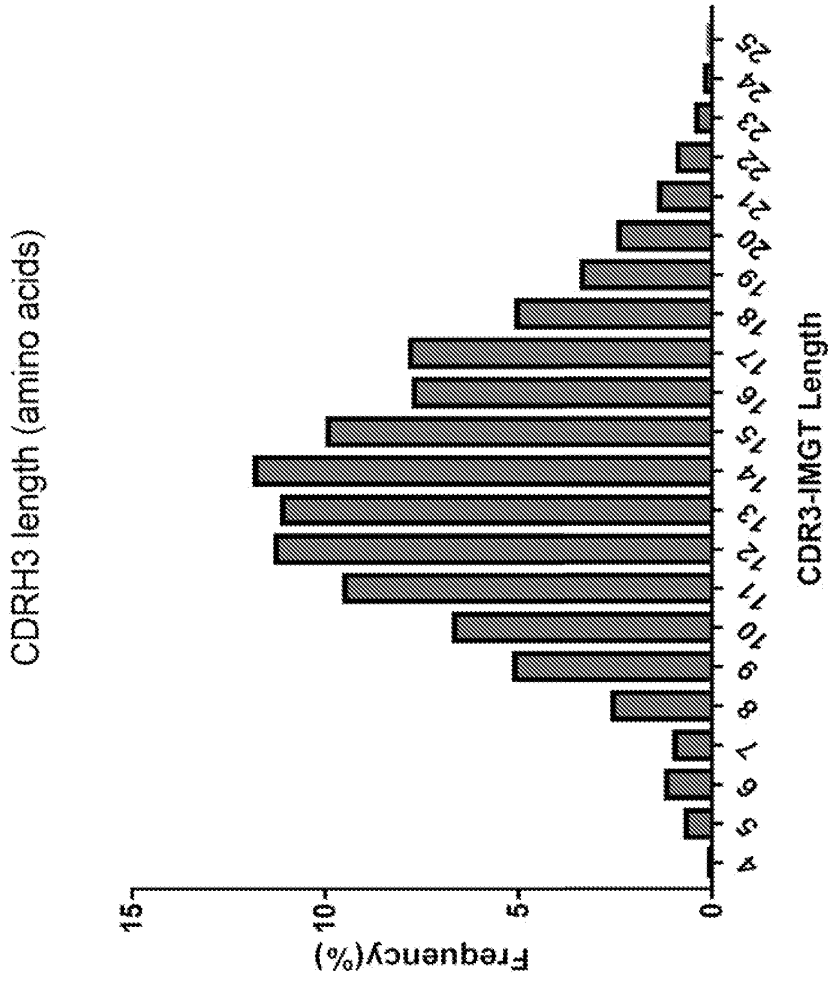

CDRH3 length (amino acids)
Frequency(%)
0
5
10
15
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
CDR3-IMGT Length

FIG. 27B

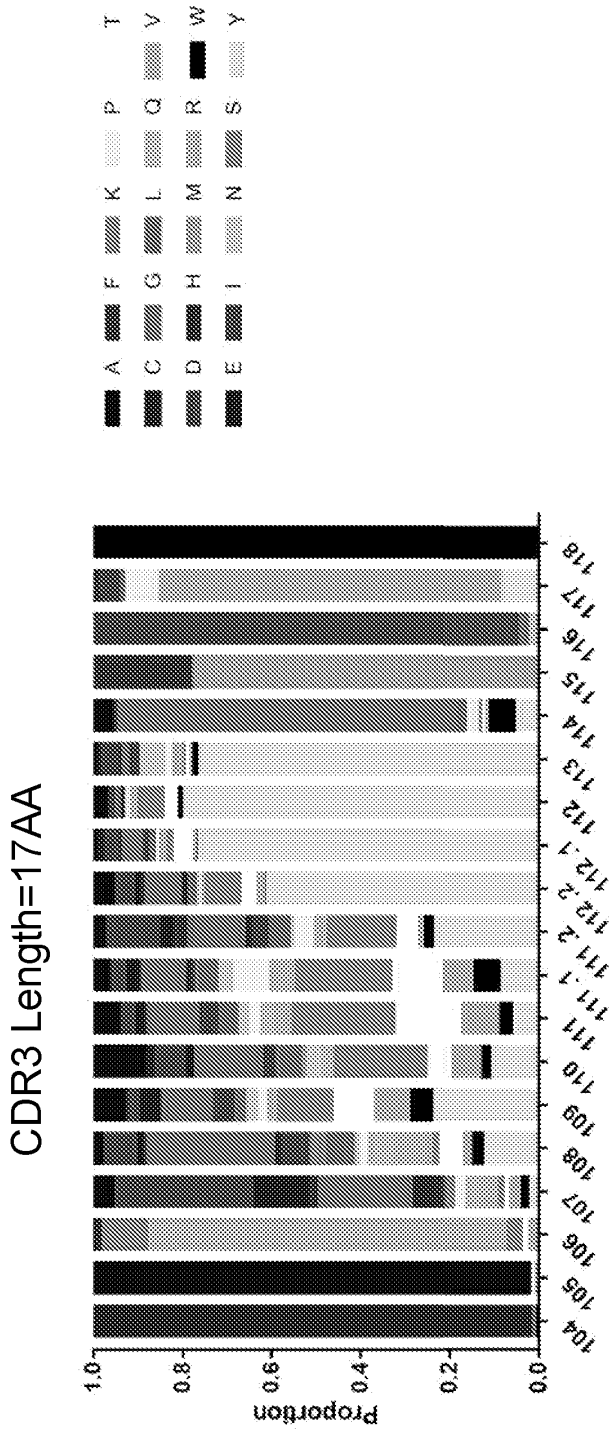

A C D E F G H I K L M N P Q R S T V W Y
CDR3 Length=17AA
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
104 105 106 107 108 109 110 111 111.1 111.2 112.2 112.1 112 113 114 115 116 117 118

FIG. 28A

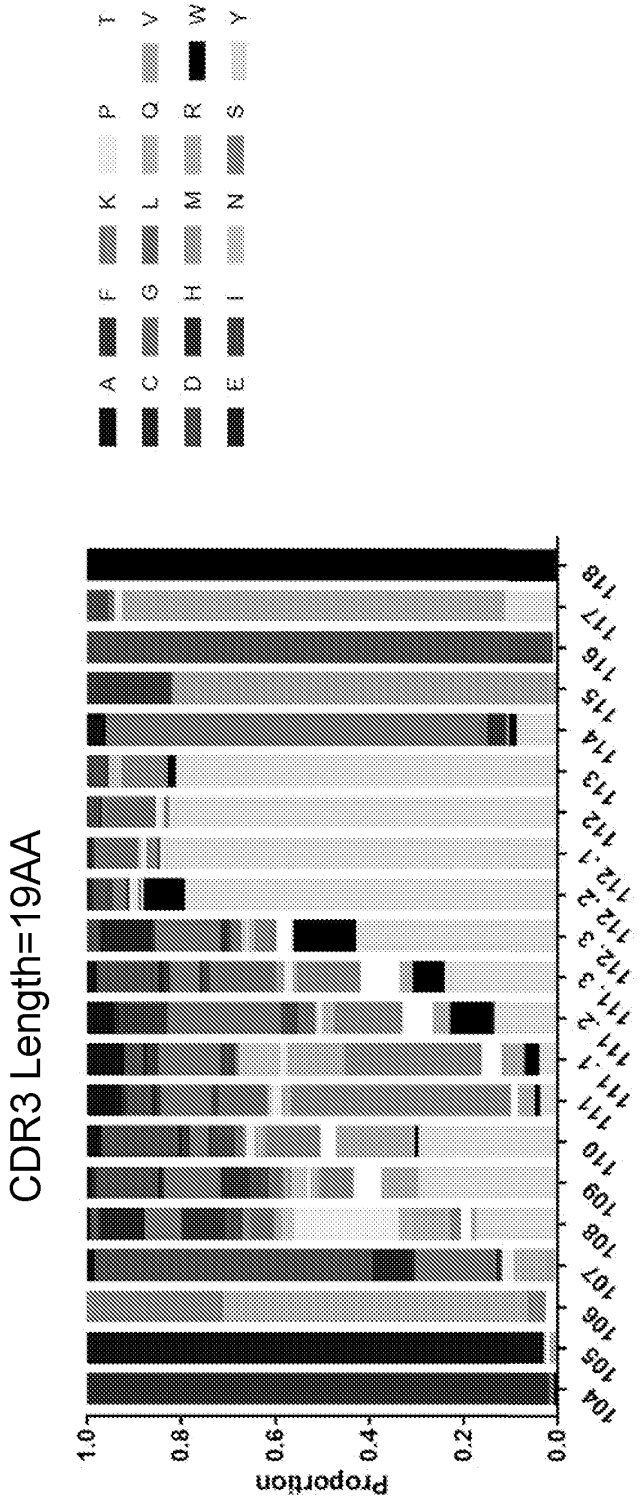

A C D E F G H I K L M N P Q R S T V W Y
CDR3 Length=19AA
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
104 105 106 107 108 109 110 111 111.1 111.2 111.3 112.3 112.2 112.1 112 113 114 115 116 117 118

FIG. 28B

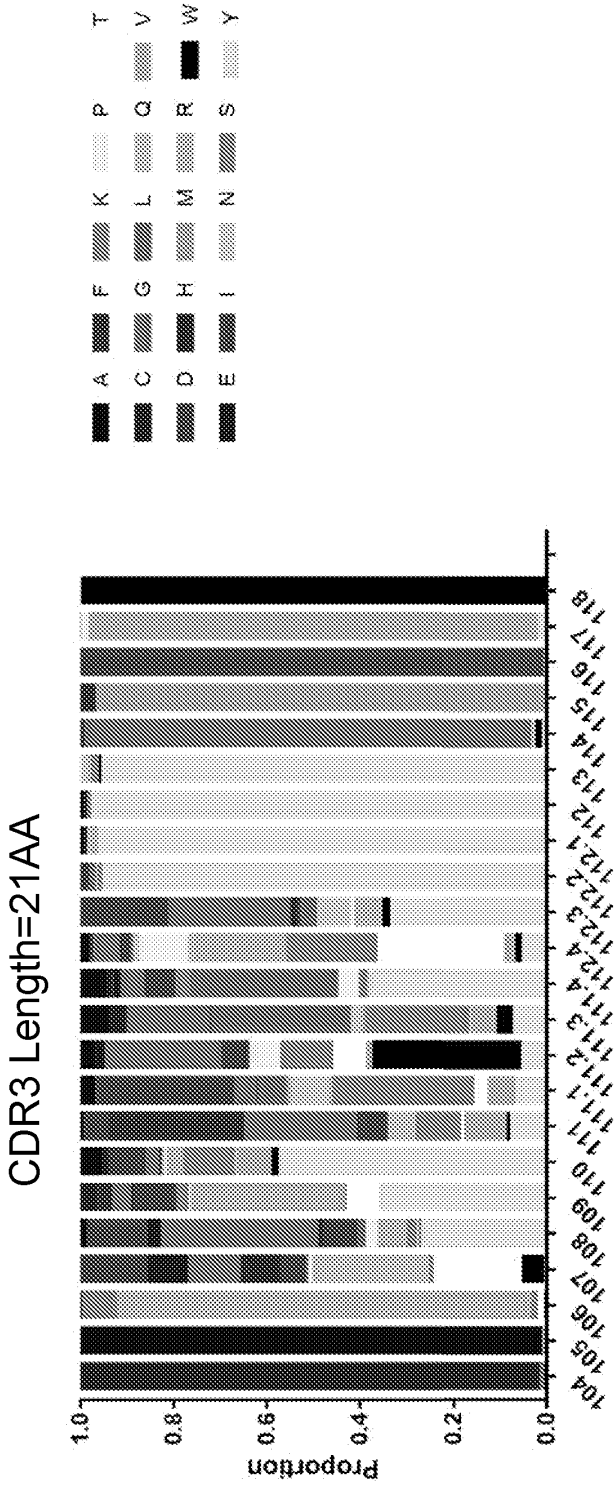

A C D E F G H I K L M N P Q R S T V W Y
CDR3 Length=21AA
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
104 105 106 107 108 109 110 111 111.1 111.2 111.3 111.4 112.4 112.3 112.2 112.1 112 113 114 115 116 117 118

FIG. 28C

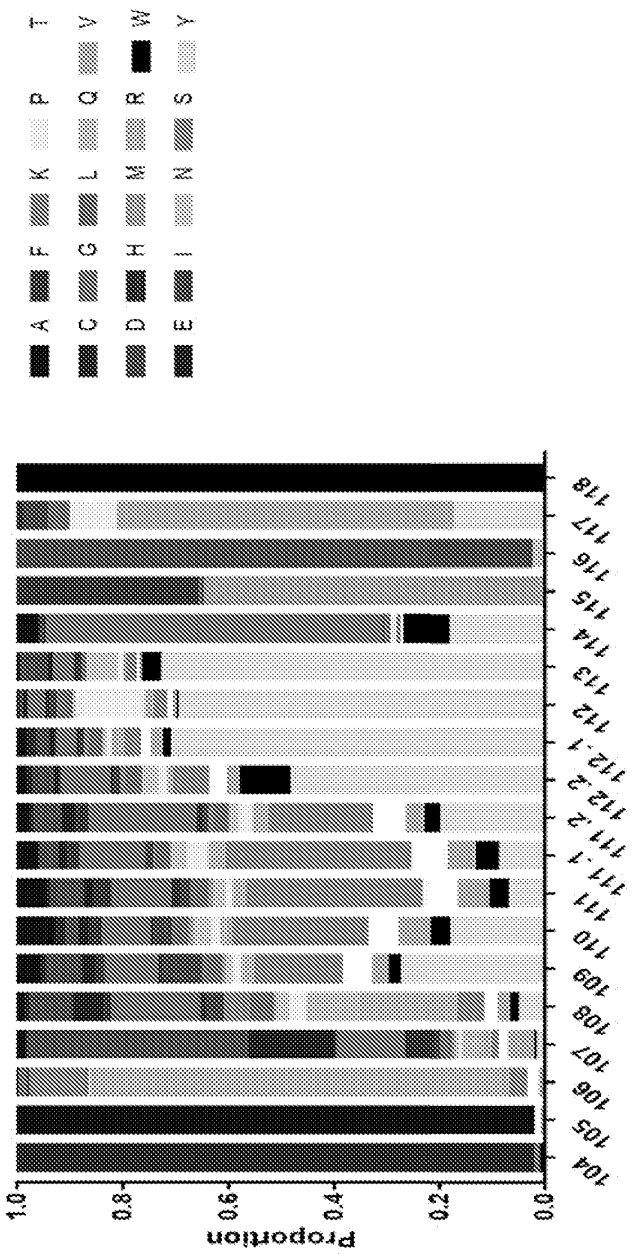

A
C
D
E
F
G
H
I
K
L
M
N
P
Q
R
S
T
V
W
Y
Proportion
1.0
0.8
0.6
0.4
0.2
0.0
104
105
106
107
108
109
110
111
111-1
111-2
112-2
112-1
112
113
114
115
116
117
118

FIG. 28D

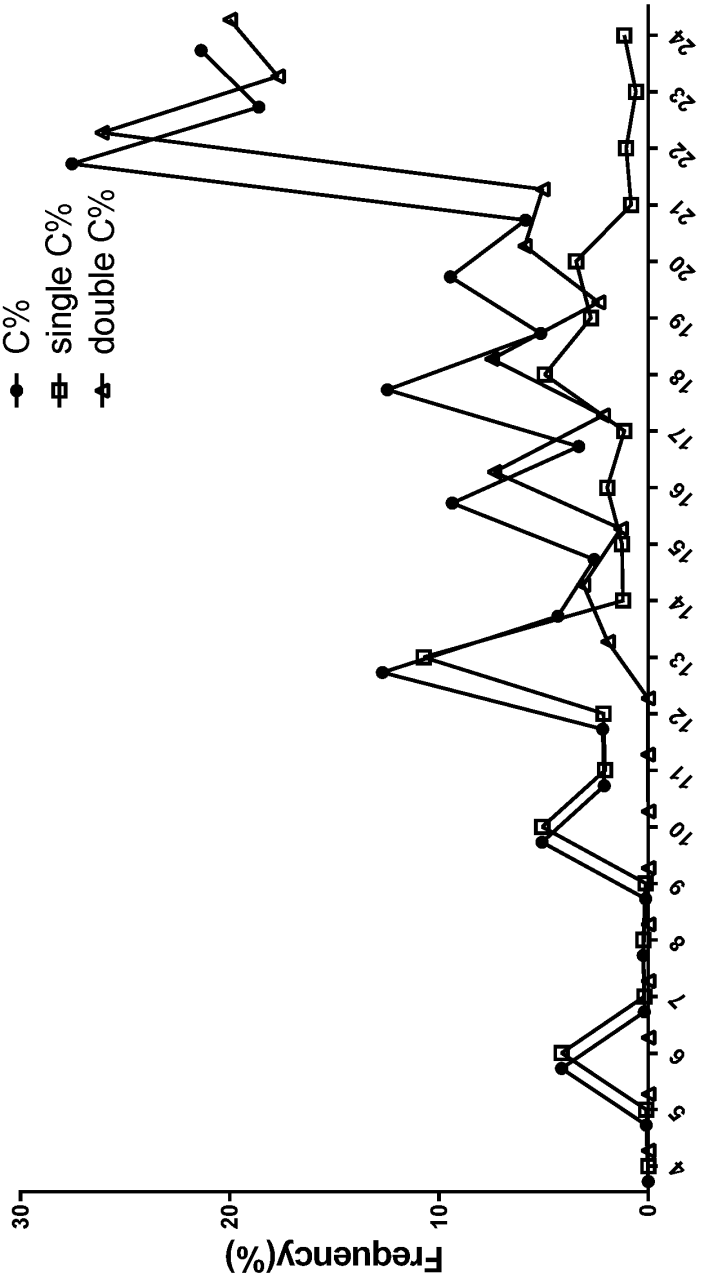

C%
single C%
double C%
Frequency(%)
0
10
20
30
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

FIG. 29

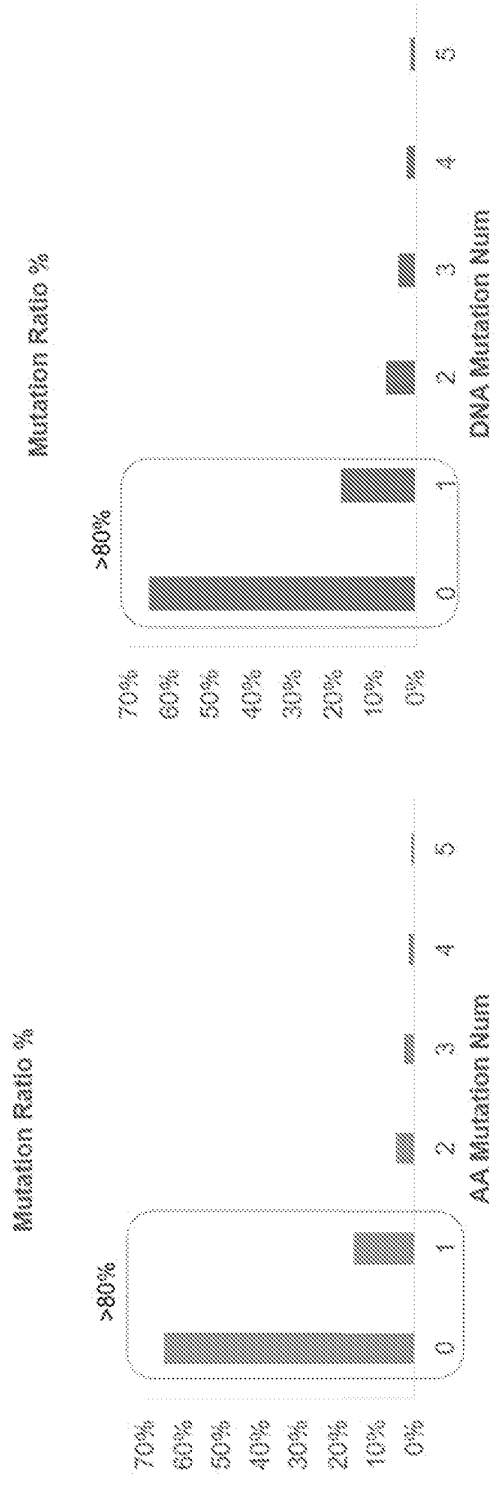


FIG. 30A

FIG. 30B

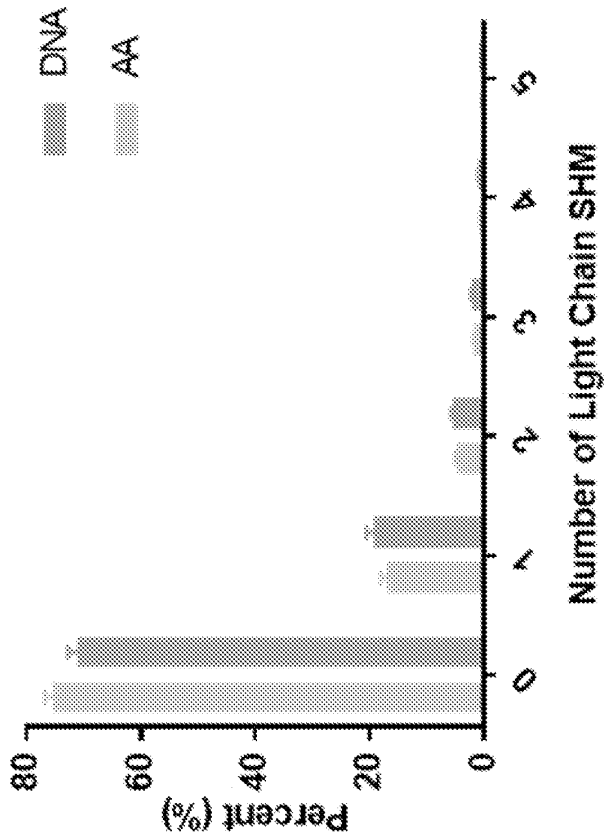


FIG. 30C

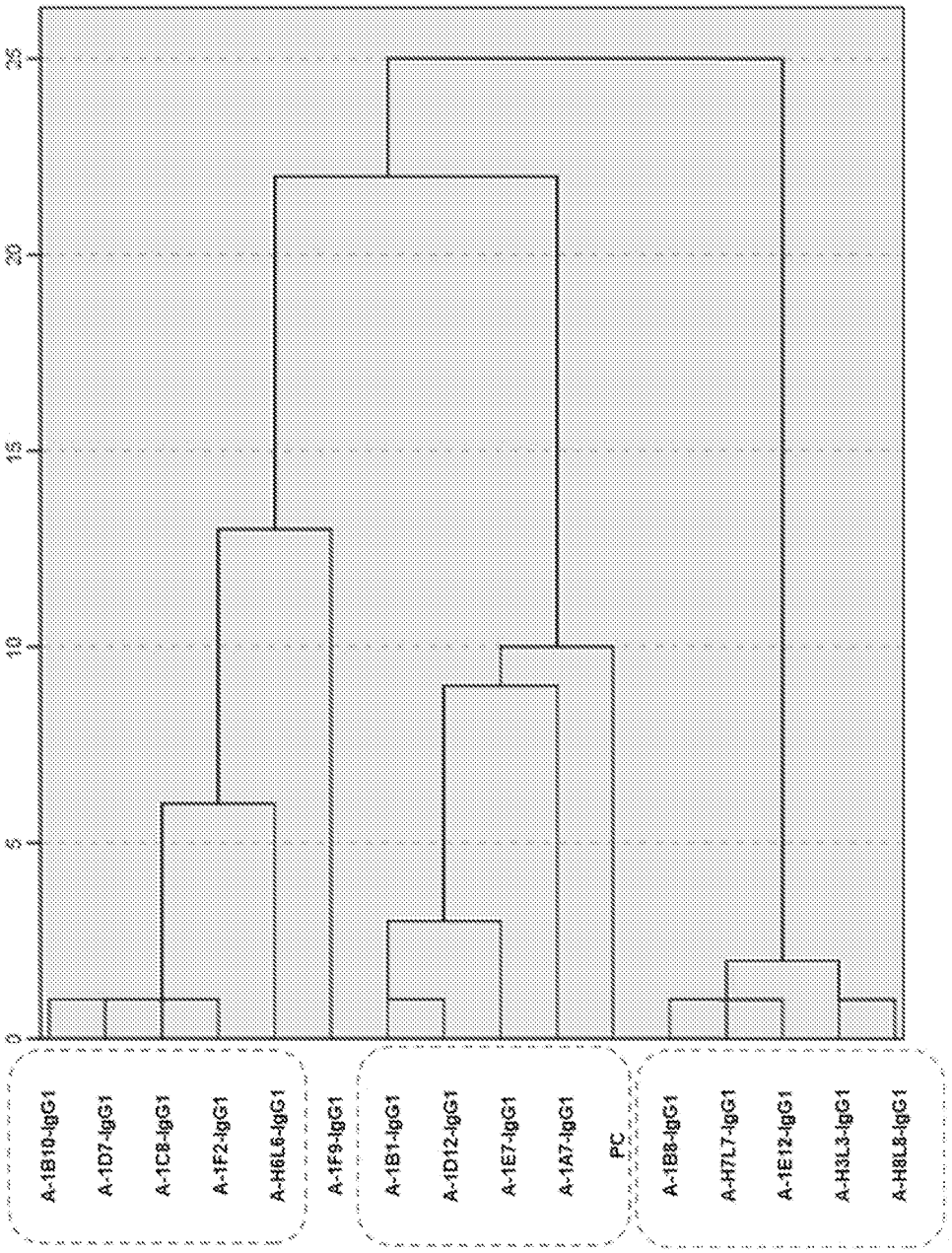

0
5
10
15
20
25
A-1B10-IgG1
A-1D7-IgG1
A-1C8-IgG1
A-1F2-IgG1
A-H6L6-IgG1
A-1F9-IgG1
A-1B1-IgG1
A-1D12-IgG1
A-1E7-IgG1
A-1A7-IgG1
PC
A-1B8-IgG1
A-H7L7-IgG1
A-1E12-IgG1
A-H3L3-IgG1
A-H8L8-IgG1

FIG. 31

FIG. 32

IGKV1-39 (SEQ ID NO:1): 477bp, 89319623 to 89320099 of NCBI accession number NC_000002.12

Atggacatgagggtcccgctcagctcctgggctcctgctactctggctccgaggtaaggatggagaacactaggaatttactcagccagtgtgctc
agtactgactggaacttcagggaagttcttctgataacatgattaatagtaagaatatttgttttatgtttccaatctcaggtgccagatgtgacatc
cagatgacccagtctccatcctccctgtctgcatctgtaggagacagagtcaccatcacttgccgggcaagtcagagcattagcagctatttaaattg
gtatcagcagaaaccagggaaagcccctaagctcctgatctatgctgcatccagtttgcaaagtggggtcccatcaaggttcagtggcagtggatctg
ggacagatttcactctcaccatcagcagtctgcaacctgaagatttttgcaacttactactgtcaacagagttacagtaccctcc

IGKV3-11 (SEQ ID NO:2): 516bp, 89027169 to 89027684 of NCBI accession number NC_000002.12

Atggaagccccagctcagcttcttcctcctgctactctggctcccaggtgagggaacatgaggtggttttgcacattagtgaaaactcttgccac
ctctgctcagcaagaaatataatttaaaattcaaagtatatcaacaattttggctctactcaaagacagttggtttgatcttgattacatgagtgcatt
tctgtttttatttccaatttcagataccaccggagaaattgtgttgacacagtctccagccaccctgtctttgtctccagggaaagagccaccctctc
ctgcagggccagtcagagtgttagcagctacttagcctggtaccaacagaaacctggccaggctcctcatctatgatgcatccaacagggcc
ccactggcatcccagccaggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagcctagagcctgaagatttttgcagtttattac
tgtcagcagcgtagcaactggcctcc

IGKV3-20 (SEQ ID NO: 3): 537bp, 89142572 to 89143108 of NCBI accession number NC_000002.12

Atggaaaccccagcgcagcttctcttcctcctgctactctggctcccaggtgaggggaacatgggatggtttgcatgtcagtgaaaaccctcctcaag
tcctgttacctggcaactctgctcagtcaatacacaataattaaagcaataaattctggctcttctgggaagacaatgggtttgattta
gattacatgggtgactttttctgtttttatttccaatctcagataccaccggagaaattgtgttgacgcagtctccaggcaccctgtctttgtctccagg
ggaaagagccaccctctccctgcagggccagtcagagtgttagcagcagctacttagcctggtaccagcagaaacctggccaggctcccaggctcctca
tctatggtgcatccagcagggccactggcatcccagacaggttcagtggcagtgggtctgggacagacttcactctcaccatcagcagactggagcct
gaagattttgcagtgtattactgtcagcagtatggtagctcacctcc

IGKJ1 (SEQ ID NO:4): 38bp, 88861886 to 88861923 of NCBI accession number NC_000002.12

gtggacgttc ggccaagggga ccaaggtgga aatcaaac

IGKJ4 (SEQ ID NO:5): 38bp, 88860886 to 88860923 of NCBI accession number NC_000002.12

gctcactttc ggcggaggga ccaaggtgga gatcaaac

Mouse 3′ UTR sequence (SEQ ID NO 6) 1189bp

gtaagtacacttttctcatctttttttatgtgtaagacacaggtttcatgttaggagttaaagtcagttcagaaaatcttgagaaaatggagagaggc
tcattatcagttgacgtggcatacagtgtcagatttctgtttatcaagctagtgagattagggcaaaaagaggctttagttgagaggaaaagtaatt
aatactatggtcaccatccaagagattggatcggagaatgagtagtattgagatctgggtctgactgcaggtagcgtggtcttctagacgt
ttaagtgggagatttggagggatgaggaacttcaggatagaaaagggctgaagtcaagttcagctccctaaaatggatgtgggagcaaac
tttgaagataaactgaatgacccagaggatgaaacagcgcagatcaaagagggcctggagctctgagaagagaaggagactcatccgtgttgagttt
ccacaagtactgtcttgagtttgcaataaaagtgggatagcagagttgagtgagccgtaggctgagtttctctctttttgtctcctaagttttttatgac
tacaaaaatcagtagtatgtcctgaaataatcattaagctgtttgaaagtatgactgcttgccatgtagataccatggcttgctgaataatcagaaga
ggtgtgactcttattctaaaatttgtcacaaaatgtcaaaatgagagactctgtaggaacgagtcctgacagacagctcaaggggttttttcctttt
gtctcatttctacatgaaagtaaatttgaaatgatctttttttattataagagtagaaatacagttgggtttgaactatatgttttaatggccacggtt
ttgtaagacatttggtcctttgtttcccagttatttatatcgccagcaatggactgaaacggtccgcaacctcttctttaca
actgggtgacctcgcggctgtgccagccatttggcgttcaccctgccgctaagggccatgtgaacccccgcggtagcatcccttgctccgcgtggacc
actttcctgaggcacagtgataggaacagagccactaatctgaagagaacagagatgtgacagactacactaatgtgagaaaaacaaggaaagggtga
cttattggagatt

Human 3′ UTR sequence (SEQ ID NO: 7) 88860567 to 88860068 of NC_000002.12

gtaagtaatttttcactattgtcttctgaaatttgggtctgatggccagtattgacttttagaggcttaaatagggagtttggtaaagattggtaaatg
agggcatttaagatttgccatgggttgcaaaagttaaactcagcttcaaaaatggattgaggagaaaaaagattaaattgctctaaactgaatgacac
aaagtaaaaaaaaaaaaagtgtaactaaaaaggaaccctttgtattctaaggagcaaaagtaaatttatttttgttcactcttgccaaatattgtattgg
ttgttgctgattatgcatgatacagaaaagtggaaaaatacatttttttagtctttctccctttttgtttgataaattatttttgtcagacacaacaataaaa
atcaatagcacgccctaagaaaaatcagggaaaagtgaagtgtaccttattgctatgtagaagaggcagcttacttgaaaatcagcagcaatgttgtt
tttagagtct

Rearranged human IGKV1-39+J4 nucleic acid sequence 3012bp (SEQ ID NO: 35)

V1-39 Promoter	**1-2000**
V1-39	**2001-2475 (the last 2 nucleotides in V1-39 are deleted)**
J4	**2476-2512 (the first nucleotide in J4 is deleted)**
Human 3′ UTR sequence	**2513-3012**

gcaggcagcatatttataatgcacagtaaacactaggaggaaacaaggcagtgagagaggaaagagagcagcgataccgaaaatgtcctcagcgagaa
gctaccacagaggatgaatggagatcaagcccacgtggaaacatgggaaaatgtctcagtatttttccacctaagaagggagggagatggggtatgta
tacacctcccctgtcctcactgattgagggctttccgagaggatgctcattccaggtgctgtgatagccatgtgtacaggcagggctgcctctccag
cttcagatagagcagtgaggaaaagatatggccatggggggtcagcagaagtacagcaaagggaaaagggtagcaagagtgacaactatatt
cacccccccacacacacacacacgaaattgtgtattgcaatccagaactgcttctctctgaacctaaatcttagcaagcagtttaccagta
actgccttgaaattcaggcccctggaaaggagcaggggttgtgtacaggctataccacagcagtctgcccaccctttagtgatgcatgagtaatgct
ccctggactcccccaggttctagtcttctcatgtcgatgtagttgattccactttcccttgctgcacaaccaggctgtgggatgcctgtgggcagaggcagaca

tgtgaggtataggggttcaaatctgtttccaagtttatccagcttcaaagcatttctccgtgtacatgagcggtggcttgacaggagatggagactc
tctttcctggatgtgaggcaaggaggcaggcgtctgagtcaggatgatgtccctactcactgctaaagagaaaagtggctttgatggtgcagggcagg
gaaatgcactgagtggtcgccacacctcacagaagagaaagtgttcactgacctggcctttcccccaggggcctctcccctcccattgctttccagaaagcc
atgatttttgagagccacacacctgaacactcacaaaacattatggtgggaaaagcagatcagagcattaggcaagttgcattaccttggccttcttcctt
tggagacaattgatgtgggttctagattgacccagagtttcaagttttatcctgattcaggcttcaacagctggaggaagaaacagagatgttttttg
aagtaaacagatctagcattactaatcaacccttcatactgatgacctatgggaaataatacccaagggcagaaaaatgggcagaataagggggagccc
caaaccaagacgaagctgctgcccattgagaccctgggtattacagagacctatagctctggataatggaagatctatgagtggcacaggcgctgagg
aatcacagcatcattatcgtgcatctgcagggaattgcttgtaaatatactggtaatttacaaatgtttaaggtcactacaaatactttggagtgtatt
aaatatgcttctgataaagactgtttttctcacatgaaacaatgggaaccatgtgacaatcacagaggtgttgttactatagcaaaagggattgttac
tctccacatccctttaagtaacttgaaggcctgatagacccacccctctaagacttcattagacatttccctacgaatggttatactctcctgtatactc
ccaatacaactctaaaatatattattccatatagtttgtattaaagtttgacttttttccttcaaaatatctcttgtcacaacagcggct
ctagagagaaatacattccctccaggcaaatctatgctgcgctggtctgacctgggaccctgggggacattgccccttgtgctgagttactaagatgagc
cagccctgcagctgtgctcagcctgccccatgccctgctgattgatttgcatgttccagagcacagccccctgccctgaagactttttatgggctgg
tcgcaccctgtgcaggagtcagtctcagtcaggacacagcatggacatgagggtccccgctcagctcctgggctcctgctactctggctccgaggta
aggatggagaacactaggaatttactcagccagtgtgctcagtactgactggaacttcagggaagttctctgataacatgattaatagtaagaatatt
tgttttatgtttccaatctcaggtgccagatgtgacatccagatgacccagtctccatcctccctgtctgcatctgtaggagacagagtcaccatca
cttgccgggcaagtcagagcattagcagctatttaaattggtatcagcagaaaccagggaaagccctaagctcctgatctatgctgcatccagtttg
caaagtggggtcccatcaaggttcagtggcagtggatctgggacagatttcactctcaccatcagcagtctgcaacctgaagatttgcaacttacta
ctgtcaacagagttacagtaccctctcacttcggcggagggaccaaggtggagatcaaacgtaagtaatttttcactattgtcttctgaaatttgg
gtctgatggccagtattgactttttagaggcttaaatagaggtttggtaaatgagggcatttaagattttgccatgggttgcaaaagtta
aactcagcttcaaaaatggatttggagaaaaaaagattaaattgctctaaactgaatgacacaaagtaaaaaaaaaaagtgtaacttaaaaaggaaccc
ttgtatttctaaggagcaaaagtaaatttatttttgttcactcttgccaaatattgtattggttgttgctgattatgcatgatacagaaaagtggaaa
aatacatttttttagtctttctccctttttgtttgataaattatttttgtcagacaacaataaaatcaatagcacgccctaagaaaaatcagggaaaagt
gaagtgtaccttatttgctatgtagaagaggcagcttacttgaaaatcagcagcaatgttgttttagagtct

Rearranged human IGKV3-11+J1 nucleic acid sequence 3051bp (SEQ ID NO: 36)

V3-11 Promoter	**1-2000**
V3-11	**2001-2516**
J1	**2517-2551 (the first 3 nucleotides in J1 are deleted)**
Human 3′ UTR sequence	**2552-3051**

caggagtgagcctggtttgatgcctctccccaacacgatagaagtgtggcacaaatctttgaaaaattcagtttccccgtggcaacaacaactacc
tgggactgaaaactcttctccctcgctctagtccttctttctacacccacttccacctcatctgtgactctacatacaatacttgtcaggaaagattctgga
aaaagcaaagagacttccttagaggtgtcagagattcctgtaccagcatctgtccatctctagaggggttgtgagtatgaggaagagcagagcttgt
caatcttctacttgctttcactcccactgtatttcctaacaacagcaaccagagcaacagccatatcatcacaggacgaacctcctcctacttccaagg
ctttatttcagtaaatctgctctacctctatctcaggcagctagaagtttgatactcatacaaatactactgcagctttctgttcataattggaaa

agtagacaagactcagtgtaatgcaggcattccttatgccagtcagcattcagttttttggatcatcattgcacacatatacccaccatgtgtctaata
tatatgtaaaaatccatgaagcaagagtcatagctagcatttgtattgtatttttcctcttatatcatcttctccttttcgtcctttaaaa
aaaatctgttcaagtcagtctaaattaattattggatgataagtagatataaaatctttttatttgataacacattgacccaatgaatatgtttctttgca
agacatagtcctcacttcccaagataacaagcctgacaaaaattatactggagcaagtcccacaagtaatgatggtagctttttccttattgtcagtcctgg
ggcaaaaataagacaaaagataacaaggtagactaaagattatgtaagaaaagaaaggcagcaggacatgggaaacttttcataggataacatttttg
ataatggatgatgaagaattaatgcgttagacagagatgggcgggaatgattgaaggtctgagcatttttagcacagattaagaccaaatcattaggatt
ttaagagttgtgtacagttagtgaagaaaaagccctagaatttaatttgactgttgataaaacatttcttggattagattgaagactcttttctgtgcc
aagtaagtatatttatgataatgatgactgtagtgctaaatatttaatcaataaaaacaaaaataattgccgcatacatacataatgtcctgagtacta
ctgtaaatgtttttatcttatttttctttaaactgtctacagcactgtaaggtaggcaccagtattgtcacagttacacagatatggaaactgagacaca
gggaagttaagttagttggtcaatttcaagcaatcggcaagccatggagcatctatgtcagggctgccaggacatgtgactgtaaacagaagtttttaa
ctttttaactcaaagagggtatgtgtctgggttaatggaaagtttcaggacccctcagaaaaacattactaacaagcaaatgaaaggtgtatctggaaga
ttaagttctaacagactccctcatttccatcgatccaataatgcacttagggagatgactgggcatattgaggatagggaagaaagacatagggaatgaaattctctgagca
ccttttatattgttcttaacaggcttgtgccaaacatcatctgggtgaatttaggtgattgaggagaaagacatagggaatgaaattctctgagca
caagggagaagttctacactcagactgagccaacagactttctggcctgacaaccagggtggcgcaggatgctcagtgcagagaggaagaagcaggt
ggtctctgcagctggaagctcagctcccacccagctgctttgcatgtccctcccagctgccctacctccagagcccatatcaatgcctgtgtcagag
ccctgggggaggaactgctcagttagggacccagaggaagccccagctcagcttcttcctcctgctactctggctcccaggtgagggga
acatgaggtggtttttgcacattagtgaaaactcttgccacctctgctcagcaagaaatataattaaaattcaaagtatatcaacaattttggctctac
tcaaagacagttggtttgatcttgattacatgagtgcatttctgtttttatttccaatttcagatacccaccggagaaattgtgttgacacagtctccag
ccacctgtctttgtctccagggaaagagccacctcctcctgcagggccagtcagagtgttagcagctacttagcctggtaccaacagaaacctggc
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catcagcagcctagagcctgaagatttttgcagttttatttactgtcagcagcgtagcaactggcctccgacgttccggccaagggaccaaggtggaaatca
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aaaatcaatagcagcacgccctaagaaaaatcagggaaaagtgaagtgtacctatttgctatgtagaagaggcagcttacttgaaaatcagcagcaatgtt
gttttagagtct

Rearranged human IGK V3-20+J1 nucleic acid sequence 3072bp (SEQ ID NO: 37)

V3-20 promoter	**1-2000**
V3-20	**2001-2535 (the last 2 nucleotides in V3-20 are deleted)**
J1	**2536-2572 (the first nucleotides in J1 is deleted)**
Human 3′ UTR sequence	**2573-3072**

agccagtggatgactatttttcttcctgagactgataatggtcattccacccaatggtccaaactacatgcagtggtaatggtcatgcaggccttttct
gccacctcttgctatatttttaccaactcatgggccactgccaacagtctagctatctgatcaggaaaatagcaaccgagtgactggactattaaagc
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gagatgaacttatgccatgtttttggatgcccactgagactttgctttgaccaaggaaagttctttactgcccaaatgacgtcaatggacacactctc
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ttattttgtcagacaacaataaaaatcaatagcacgccctaagaaaaatcagggaaaagtgaagtgtacctatttgctatgtagaagaggcagcttac
ttgaaaatcagcagcaatgttgtttttagagtct

Amino acid sequence of common light chain VL encoded by human IGKV1-39/IGKJ4 (SEQ ID NO: 38)
DIQMTQSPSSLSASVGDRVTITCRASQSISSYLNWYQQKPGKAPKLLIYAASSLQSGVPSRFSGSGSGTDFTLTISSLQPEDFATYYCQQSYSTPLTF
GGGTKVEIK

Amino acid sequence of common light chain VL encoded by human IGKV3-11/IGKJ1 (SEQ ID NO: 39)

EIVLTQSPATLSLSPGERATLSCRASQSVSSYLAWYQQKPGQAPRLLIYDASNRATGIPARFSGSGSGTDFTLTISSLEPEDFAVYYCQQRSNWPPTF
GQGTKVEIK

Amino acid sequence of common light chain VL encoded by human IGKV3-20/IGKJ1 (SEQ ID NO: 40)
EIVLTQSPGTLSLSPGERATLSCRASQSVSSYLAWYQQKPGQAPRLLIYGASSRATGIPDRFSGSGSGTDFTLTISRLEPEDFAVYYCQQYGSSPWT
FGQGTKVEIK

Mouse kappa chain constant domain (SEQ ID NO: 41)
RADAAPTVSIFPPSSEQLTSGGASVVCFLNNFYPKDINVKWKIDGSERQNGVLNSWTDQDSKDSTYSMSSTLTLTKDEYERHNSYTCEATHKTSTSPI
VKSFNRNEC

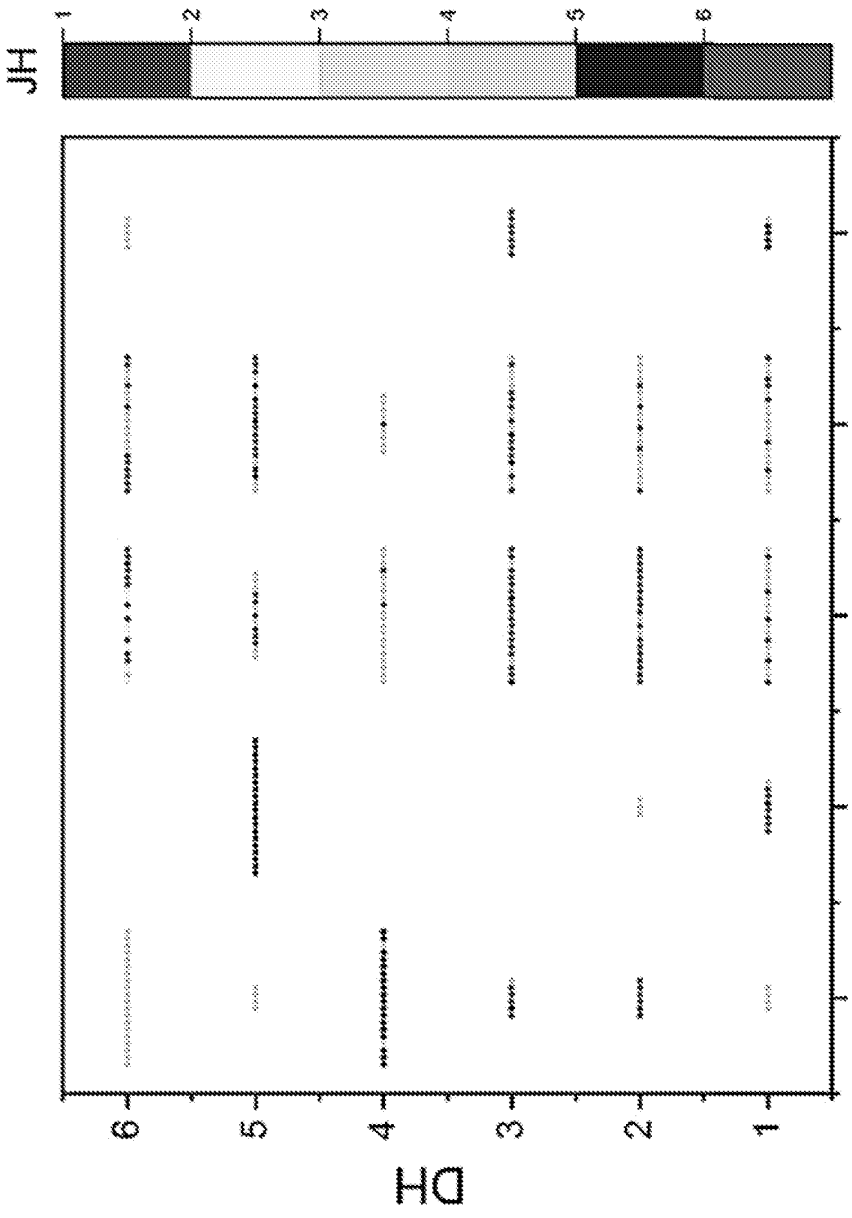


FIG. 33A

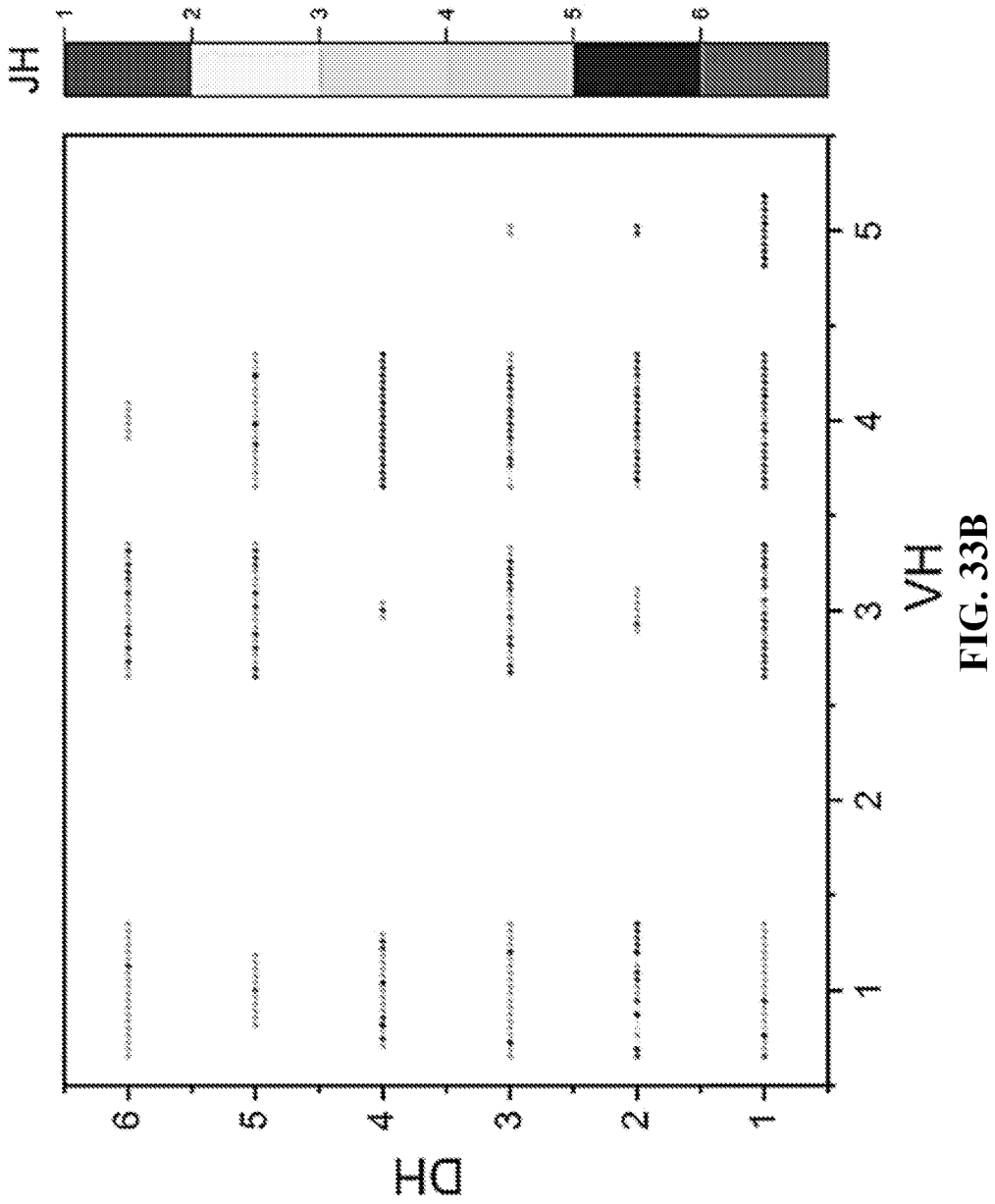
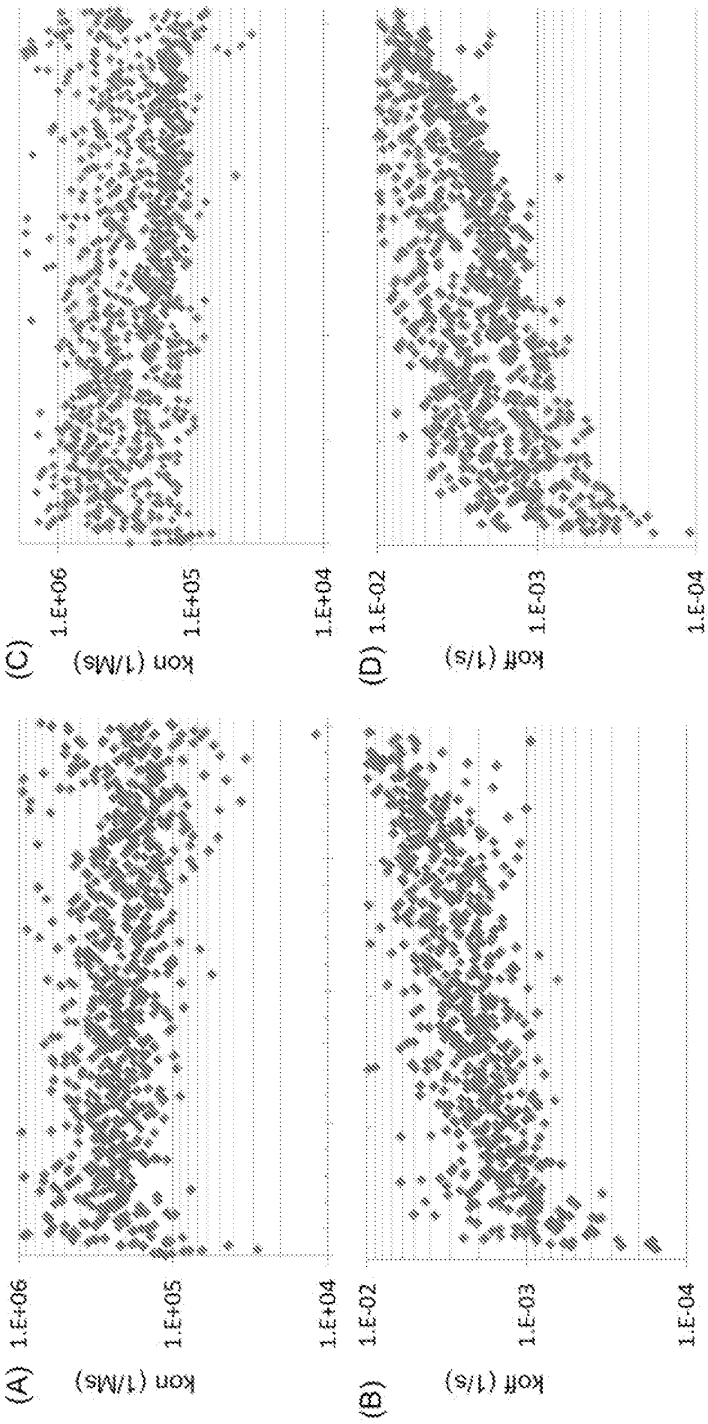


FIG. 33B


(A)
kon (1/Ms)
1.E+06
1.E+05
1.E+04
(B)
koff (1/s)
1.E-02
1.E-03
1.E-04
(C)
kon (1/Ms)
1.E+06
1.E+05
1.E+04
(D)
koff (1/s)
1.E-02
1.E-03
1.E-04

FIGS.34A-34D



FIG.35A



FIG.35B