Experimental and Clinical Immunogenetics

Exp Clin Immunogenet 2001;18:242–254 Received: March 17, 2001

Nomenclature of the Human Immunoglobulin Lambda (IGL) Genes

Marie-Paule Lefranc

IMGT Nomenclature Committee, CNRS, Université Montpellier II, Montpellier, France

Key Words

Human · IMGT · Immunoglobulin · Lambda chain genes · Orphons

Abstract

'Nomenclature of the Human Immunoglobulin Lambda (IGL) Genes', the 18th report of the 'IMGT Locus in Focus' section, provides the first complete list of all the human IGL genes. The total number of human IGL genes per haploid genome is 87–96 (93–102 if the orphons are included), of which 37–43 genes are functional. IMGT/Human Genome Organization (HUGO) gene names and definitions of the human IGL genes on chromosome 22q11.2 and IGL orphons on chromosomes 8 and 22 are provided with the gene functionality and the number of alleles, according to the rules of the IMGT Scientific chart, with the accession numbers of the IMGT reference sequences and with the accession ID of the Genome Database GDB and NCBI LocusLink databases, in which all the IMGT human IGL genes have been entered. The tables are available at the **IMGT** Marie-Paule page of IMGT, the international ImMunoGeneTics database **(http://imgt.cines.fr)** created by Marie-Paule Lefranc, Université Montpellier II, CNRS, France.

Introduction

'Nomenclature of the Human Immunoglobulin Lambda (IGL) Genes' is the 18th report of the 'IMGT Locus in Focus' section launched in the April 1998 issue of *Experimental and Clinical Immunogenetics* [1–18]. This report comprises three tables and three figures entitled, respectively: (1) Complete list of the human IGL genes on chromosome 22 at 22q11.2; (2) Human IGL orphons on chromosomes 8 and 22; (3) Correspondence between the human IGLV gene nomenclatures; (4) Chromosomal localization of the human IGL locus at 22q11.2; (5) Representation of the

KARGER

Fax + 41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

0254–9670/01/0184–0242$17.50/0

Accessible online at:
www.karger.com/journals/eci

Prof. Marie-Paule Lefranc, IMGT
Laboratoire d'ImmunoGénétique Moléculaire, LIGM UPR CNRS 1142
IGH, 141 rue de la Cardonille, F–34396 Montpellier Cedex 5 (France)
Tel. +33 4 99 61 99 65, Fax +33 4 99 61 99 01
E-Mail lefranc@ligm.igh.cnrs.fr, IMGT: http://imgt.cines.fr

human IGL locus at 22q11.2, and (6) The CLASSIFICATION concept of the IMGT-ONTOLOGY, exemplified for the IGLV genes. The tables provide the first complete list of all the human IGL genes. The total number of human IGL genes per haploid genome is 87–96 depending on the haplotypes (93–102 if the orphons are included), of which 37–43 genes are functional. IMGT/Human Genome Organization (HUGO) gene names and definitions of the human IGL genes on chromosome 22q11.2 and IGL orphons on chromosomes 8 and 22 are provided with the gene functionality and the number of alleles, according to the rules of the IMGT Scientific chart, with the accession numbers of the IMGT reference sequences and with the accession ID of the Genome Database GDB and NCBI LocusLink databases, in which all the IMGT human IGL genes have been entered. Detailed references for individual IGLV, IGLJ and IGLC genes are available in other reports [2, 7, 19]. These tables and figures are available at the IMGT Marie-Paule page of **IMGT**, the international ImMunoGeneTics database **(http://imgt.cines.fr)** created by Marie-Paule Lefranc, Université Montpellier II, CNRS, Montpellier, France [20–23].

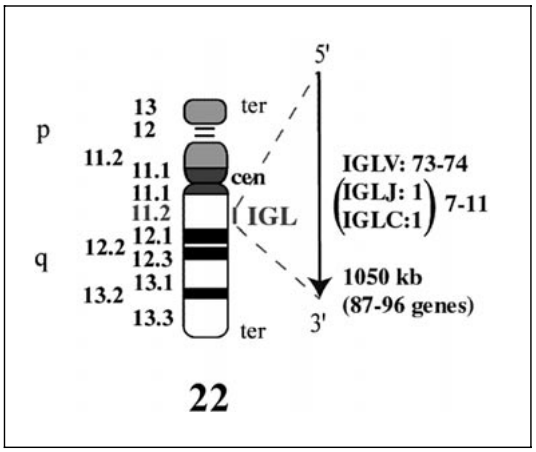

Fig. 1. Chromosomal localization of the human IGL locus at 22q11.2. The vertical line indicates the localization of the IGL locus at 22q11.2. The arrow indicates the orientation 5′ → 3′ of the locus, and the gene group order in the locus. The arrow is proportional to the size of the locus, indicated in kilobases (kb). The total number of genes in the locus is shown between parentheses. Depending on the haplotype, there are 7–11 IGLC genes. In the 7-IGLC gene haplotype, each IGLC gene is preceded by one IGLJ gene in 5′. Although the additional IGLC genes, in the 8-, 9-, 10- and 11-IGLC gene haplotypes have not yet been sequenced, they are probably preceded by one IGLJ gene. The number of functional genes defines the potential IGL repertoire, which comprises in the 7-IGLC gene haplotype, 37–43 genes (29–33 IGLV, 4–5 IGLJ and 4–5 IGLC) per haploid genome.

Human IGL Locus at 22q11.2

The human IGL locus is located at band 22q11.2 on the long arm of chromosome 22 [24, 25] (fig. 1). The orientation of the locus has been determined by the analysis of translocations involving the IGL locus in leukemia and lymphoma. Sequencing of the long arm of chromosome 22 showed that it encompasses about 35 megabases of DNA and that the IGL locus is localized at 6 megabases from the centromere [26].

The human IGL locus at 22q11.2 spans 1,050 kb (fig. 2). It consists of 73–74 IGLV genes [2, 7, 27–30], localized on 900 kb, 7–11 IGLJ and 7–11 IGLC genes depending on the haplotypes, each IGLC gene being preceded by one IGLJ gene [31–34] (table 1). Fifty-six to 57 IGLV genes belong to 11 subgroups, whereas 17 pseudogenes which are too divergent to be assigned to subgroups, have been assigned to the clans (see header of table 1). The 5′-most IGLV genes occupy the more centromeric position, whereas the IGLC genes, in 3′ of the locus, are the most telomeric genes in the IGL locus. The potential genomic IGL repertoire comprises 29–33 func-

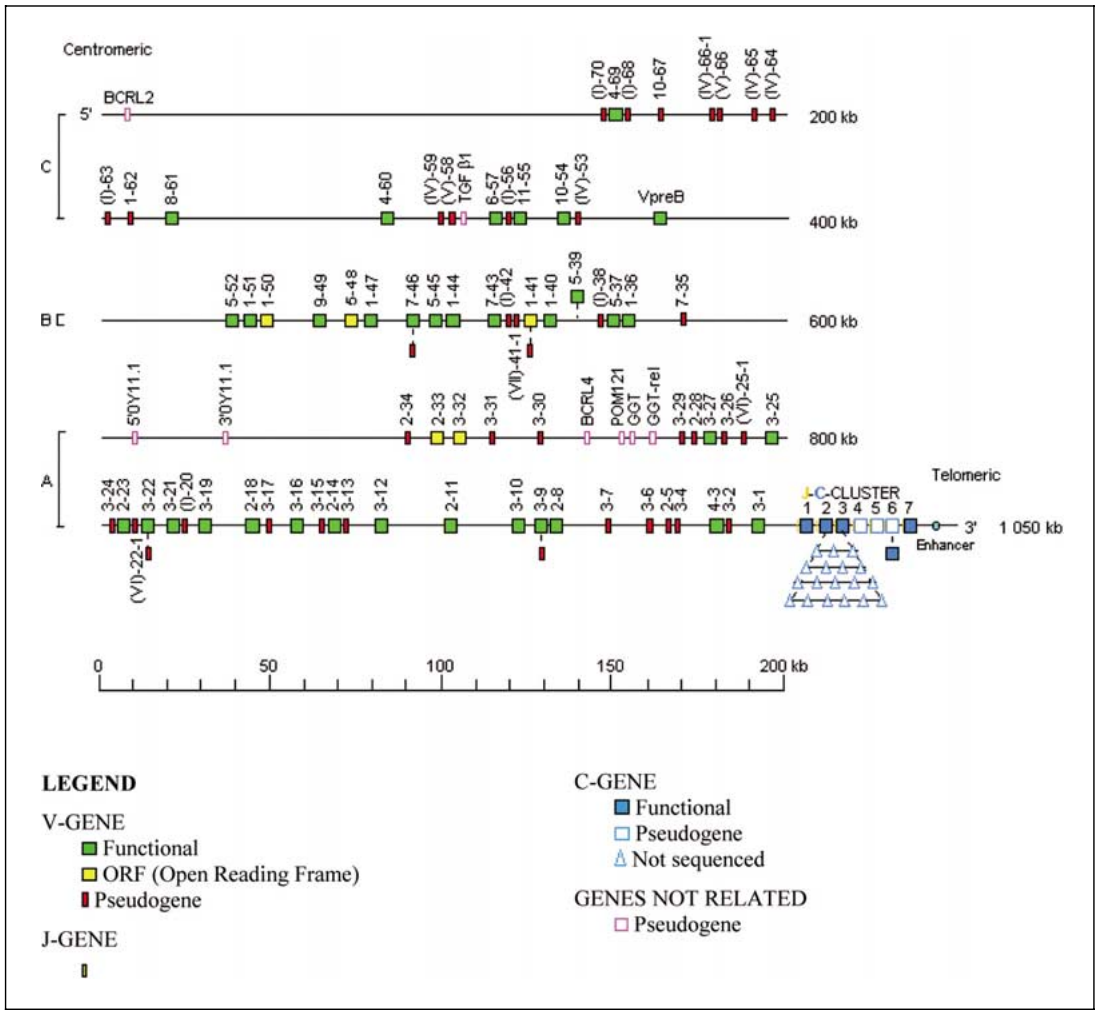

Fig. 2. Representation of the human IGL locus at 22q11.2. The boxes representing the genes are not to scale. Exons are not shown. **A**, **B**, **C** refer to three distinct V-CLUSTERs based on the IGLV gene subgroup content [29]. IGLV gene names are designated by a number for the subgroup [27, 29] followed by a hyphen and a number for the localization from 3′ to 5′ in the locus. Pseudogenes which could not be assigned to subgroups with functional genes are designated by a Roman numeral between parentheses, corresponding to the clans, followed by a hyphen and a number for the localization from 3′ to 5′ in the locus.

tional IGLV genes belonging to 10 subgroups, 4–5 IGLJ, and 4–5 IGLC functional genes in the 7-IGLC gene haplotype. One, 2, 3 or 4 additional IGLC genes, each one probably preceded by 1 IGLJ, have been shown to characterize IGLC haplotypes with 8, 9, 10 or 11 genes [32, 35–37], but these genes have not yet been sequenced. The number of human IGL genes at 22q11.2 is 87–96 of which 37–43 genes are functional [19].

Table 1. Complete list of the human IGL genes on chromosome 22 at 22q11.2

IGLV gene nomenclature: IGLV genes are designated by a number for the subgroup, followed by a hyphen and a number for the localization from 3′ to 5′ in the locus [19, 27, 29]. In the IGLV gene name column, the IGLV genes are listed, for each subgroup, according to their position from 3′ to 5′ in the locus. Pseudogenes which could not be assigned to subgroups with functional genes are designated by a Roman numeral between parentheses, corresponding to the clans, followed by a hyphen and a number for the localization from 3′ to 5′ in the locus. Clans comprise, respectively:
– clan I: IGLV1, IGLV2, IGLV6 and IGLV10 subgroup genes, and pseudogenes IGLV(I)-20, -38, -42, -56, -63, -68 and -70
– clan II: IGLV3 subgroup genes
– clan III : IGLV7 and IGLV8 subgroup genes
– clan IV : IGLV5 and IGLV11 subgroup genes, and pseudogenes IGLV(IV)-53, -59, -64, -65 and 66-1. IGLV(IV)-66-1 has been identified in D87004 by IMGT curators (G. Folch, V. Giudicelli and M.-P. Lefranc)
– clan V : IGLV4 and IGLV9 subgroup genes, and pseudogenes IGLV(V)-58 and -66
– clan VI : pseudogenes IGLV(VI)-22-1 and -25-1. IGLV(VI)-25-1 has been identified in D86994 by IMGT curators (N. Bosc and M.-P. Lefranc)
– clan VII : pseudogene IGLV(VII)-41-1.
An asterisk (*)indicates an allelic polymorphism by insertion/deletion which concerns the IGLV5-39 gene. One, two, three or four additional IGLC genes, each one probably preceded by one IGLJ, have been shown to characterize IGLC haplotypes with 8, 9, 10 or 11 genes [32, 35, 36], but these genes have not yet been sequenced and are not shown in this table.

IMGT gene group	IMGT gene name (1)	IMGT func-tionality	IMGT reference sequence accession numbers	Number of alleles	IMGT gene definition (2)	GDB accession ID (3)	LocusLink accession ID (3)
IGLC	IGLC1	F	J00252	3	Immunoglobulin lambda constant 1	GDB:120690	3537
	IGLC2	F	J00253	2	Immunoglobulin lambda constant 2	GDB:120691	3538
	IGLC3	F	J00254	4	Immunoglobulin lambda constant 3	GDB:120692	3539
	IGLC4	P	J03009	2	Immunoglobulin lambda constant 4	GDB:120693	3540
	IGLC5	P	J03010	2	Immunoglobulin lambda constant 5	GDB:120694	3541
	IGLC6	F, P	J03011	5	Immunoglobulin lambda constant 6	GDB:120524	3542
	IGLC7	F	X51755	2	Immunoglobulin lambda constant 7	GDB:9953636	28834
IGLJ	IGLJ1	F	X04457	1	Immunoglobulin lambda joining 1	GDB:9953638	28833
	IGLJ2	F	M15641	1	Immunoglobulin lambda joining 2	GDB:9953640	28832
	IGLJ3	F	M15642	2	Immunoglobulin lambda joining 3	GDB:9953642	28831
	IGLJ4	ORF	X51755	1	Immunoglobulin lambda joining 4	GDB:9953644	28830
	IGLJ5	ORF	X51755	2	Immunoglobulin lambda joining 5	GDB:9953646	28829
	IGLJ6	ORF	M18338	1	Immunoglobulin lambda joining 6	GDB:9953648	28828
	IGLJ7	F	X51755	2	Immunoglobulin lambda joining 7	GDB:9953650	28827
IGLV	IGLV1-36	F	Z73653	1	Immunoglobulin lambda variable 1-36	GDB:9953652	28826
	IGLV1-40	F	M94116	3	Immunoglobulin lambda variable 1-40	GDB:9953654	28825
	IGLV1-41	ORF, P	M94118	2	Immunoglobulin lambda variable 1-41	GDB:9953656	28824
	IGLV1-44	F	Z73654	1	Immunoglobulin lambda variable 1-44	GDB:9953658	28823
	IGLV1-47	F	Z73663	2	Immunoglobulin lambda variable 1-47	GDB:9953660	28822
	IGLV1-50	ORF	M94112	1	Immunoglobulin lambda variable 1-50	GDB:9953662	28821
	IGLV1-51	F	Z73661	2	Immunoglobulin lambda variable 1-51	GDB:9953664	28820

➤

Table 1 (continued)

IMGT gene group	IMGT gene name (1)	IMGT func-tionality	IMGT reference sequence accession numbers	Number of alleles	IMGT gene definition (2)	GDB accession ID (3)	LocusLink accession ID (3)
	IGLV1-62	P	D87022	–	Immunoglobulin lambda variable 1-62	GDB:9953666	28819
	IGLV2-5	P	Z73641	–	Immunoglobulin lambda variable 2-5	GDB:9953668	28818
	IGLV2-8	F	X97462	3	Immunoglobulin lambda variable 2-8	GDB:9953670	28817
	IGLV2-11	F	Z73657	3	Immunoglobulin lambda variable 2-11	GDB:9953674	28816
	IGLV2-14	F	Z73664	4	Immunoglobulin lambda variable 2-14	GDB:9953676	28815
	IGLV2-18	F	Z73642	4	Immunoglobulin lambda variable 2-18	GDB:9953679	28814
	IGLV2-23	F	X14616	3	Immunoglobulin lambda variable 2-23	GDB:9953681	28813
	IGLV2-28	P	X97466	–	Immunoglobulin lambda variable 2-28	GDB:9953683	28812
	IGLV2-33	ORF	Z73643	3	Immunoglobulin lambda variable 2-33	GDB:9953685	28811
	IGLV2-34	P	D87013	–	Immunoglobulin lambda variable 2-34	GDB:9953687	28810
	IGLV3-1	F	X57826	1	Immunoglobulin lambda variable 3-1	GDB:9953689	28809
	IGLV3-2	P	X97468	–	Immunoglobulin lambda variable 3-2	GDB:9953691	28808
	IGLV3-4	P	D87024	–	Immunoglobulin lambda variable 3-4	GDB:9953693	28807
	IGLV3-6	P	X97465	–	Immunoglobulin lambda variable 3-6	GDB:9953695	28806
	IGLV3-7	P	X97470	–	Immunoglobulin lambda variable 3-7	GDB:9953697	28805
	IGLV3-9	F, P	X97473	3	Immunoglobulin lambda variable 3-9	GDB:9953699	28804
	IGLV3-10	F	X97464	2	Immunoglobulin lambda variable 3-10	GDB:9953701	28803
	IGLV3-12	F	Z73658	2	Immunoglobulin lambda variable 3-12	GDB:9953703	28802
	IGLV3-13	P	X97463	–	Immunoglobulin lambda variable 3-13	GDB:9953705	28801
	IGLV3-15	P	D87015	–	Immunoglobulin lambda variable 3-15	GDB:9953707	28800
	IGLV3-16	F	X97471	1	Immunoglobulin lambda variable 3-16	GDB:9953709	28799
	IGLV3-17	P	X97472	–	Immunoglobulin lambda variable 3-17	GDB:9953711	28798
	IGLV3-19	F	X56178	1	Immunoglobulin lambda variable 3-19	GDB:9953713	28797
	IGLV3-21	F	X71966	3	Immunoglobulin lambda variable 3-21	GDB:9953715	28796
	IGLV3-22	F, P	Z73666	2	Immunoglobulin lambda variable 3-22	GDB:9953717	28795
	IGLV3-24	P	X71968	–	Immunoglobulin lambda variable 3-24	GDB:9953719	28794
	IGLV3-25	F	X97474	3	Immunoglobulin lambda variable 3-25	GDB:9953721	28793
	IGLV3-26	P	X97467	–	Immunoglobulin lambda variable 3-26	GDB:9953723	28792
	IGLV3-27	F	D86994	1	Immunoglobulin lambda variable 3-27	GDB:9953725	28791
	IGLV3-29	P	Z73644	–	Immunoglobulin lambda variable 3-29	GDB:9953727	28790
	IGLV3-30	P	Z73646	–	Immunoglobulin lambda variable 3-30	GDB:9953729	28789
	IGLV3-31	P	X97469	–	Immunoglobulin lambda variable 3-31	GDB:9953731	28788
	IGLV3-32	ORF	Z73645	1	Immunoglobulin lambda variable 3-32	GDB:9953733	28787
	IGLV4-3	F	X57828	1	Immunoglobulin lambda variable 4-3	GDB:9953735	28786
	IGLV4-60	F	Z73667	3	Immunoglobulin lambda variable 4-60	GDB:9953737	28785
	IGLV4-69	F	Z73648	2	Immunoglobulin lambda variable 4-69	GDB:9953739	28784
	IGLV5-37	F	Z73672	1	Immunoglobulin lambda variable 5-37	GDB:9953741	28783
	(*)IGLV5-39	F	Z73668	2	Immunoglobulin lambda variable 5-39	GDB:9953743	28782

IGLV5-45	F	Z73670	3	Immunoglobulin lambda variable 5-45	GDB:9953745	28781
IGLV5-48	ORF	Z73649	1	Immunoglobulin lambda variable 5-48	GDB:9953747	28780
IGLV5-52	F	Z73669	1	Immunoglobulin lambda variable 5-52	GDB:9953749	28779
IGLV6-57	F	Z73673	1	Immunoglobulin lambda variable 6-57	GDB:9953751	28778
IGLV7-35	P	Z73660	–	Immunoglobulin lambda variable 7-35	GDB:9953753	28777
IGLV7-43	F	X14614	1	Immunoglobulin lambda variable 7-43	GDB:9953755	28776
IGLV7-46	F, P	Z73674	3	Immunoglobulin lambda variable 7-46	GDB:9953757	28775
IGLV8-61	F	Z73650	3	Immunoglobulin lambda variable 8-61	GDB:9953759	28774
IGLV9-49	F	Z73675	3	Immunoglobulin lambda variable 9-49	GDB:9953761	28773
IGLV10-54	F	Z73676	3	Immunoglobulin lambda variable 10-54	GDB:9953763	28772
IGLV10-67	P	Z73651	–	Immunoglobulin lambda variable 10-67	GDB:9953765	28771
IGLV11-55	ORF	D86996	1	Immunoglobulin lambda variable 11-55	GDB:9953767	28770
IGLV(I)-20	P	D87007	–	Immunoglobulin lambda variable (I)-20	GDB:9953769	28769
IGLV(I)-38	P	D87009	–	Immunoglobulin lambda variable (I)-38	GDB:9953771	28768
IGLV(I)-42	P	X14613	–	Immunoglobulin lambda variable (I)-42	GDB:9953773	28767
IGLV(I)-56	P	D86996	–	Immunoglobulin lambda variable (I)-56	GDB:9953775	28766
IGLV(I)-63	P	D87022	–	Immunoglobulin lambda variable (I)-63	GDB:9953777	28765
IGLV(I)-68	P	D86993	–	Immunoglobulin lambda variable (I)-68	GDB:9953779	28764
IGLV(I)-70	P	D86993	–	Immunoglobulin lambda variable (I)-70	GDB:9953781	28763
IGLV(IV)-53	P	D86996	–	Immunoglobulin lambda variable (IV)-53	GDB:9953783	28762
IGLV(IV)-59	P	D87000	–	Immunoglobulin lambda variable (IV)-59	GDB:9953785	28761
IGLV(IV)-64	P	D87022	–	Immunoglobulin lambda variable (IV)-64	GDB:9953787	28760
IGLV(IV)-65	P	D87022	–	Immunoglobulin lambda variable (IV)-65	GDB:9953789	28759
IGLV(IV)-66-1	P	D87004	–	Immunoglobulin lambda variable (IV)-66-1	GDB:9991231	84097
IGLV(V)-58	P	D87000	–	Immunoglobulin lambda variable (V)-58	GDB:9953791	28758
IGLV(V)-66	P	D87004	–	Immunoglobulin lambda variable (V)-66	GDB:9953793	28757
IGLV(VI)-22-1	P	X71351	–	Immunoglobulin lambda variable (VI)-22-1		84091
IGLV(VI)-25-1	P	D86994	–	Immunoglobulin lambda variable (VI)-25-1		84090
IGLV(VII)-41-1	P	X99568	–	Immunoglobulin lambda variable (VII)-41-1		84089

(1) IMGT gene names have been approved by the Human Genome Organization (HUGO) Nomenclature Committee in 1999. Note that, in the HUGO symbols, parentheses in the names of pseudogenes assigned to clans are omitted. Otherwise all the gene names (gene symbols) are identical in IMGT and HUGO nomenclatures.

(2) Gene definitions (full names) are identical (including parentheses) in IMGT and HUGO nomenclatures.

(3) Other entries concerning the IGL locus or groups, in the OMIM, GDB, and LocusLink genome databases, and in HUGO:

IMGT designation	IMGT definition[a]	OMIM	GDB	LocusLink	HUGO
IGL locus	Immunoglobulin lambda locus	–	GDB:128432	3535	IGL@
IGLC group	Immunoglobulin lambda constant group	147220	GDB:9955887	3536	IGLC@
GLJ group	Immunoglobulin lambda joining group	147230	GDB:9954615	8217	IGLJ@

[a] Entry definitions are identical in IMGT, GDB, LocusLink and HUGO.

Table 2. Human IGL orphons on chromosomes 8 and 22

a On chromosome 8 at 8q11.2

IMGT gene group	IMGT gene name (1)	IMGT func-tionality	IMGT reference sequence accession numbers	Number of alleles	IMGT gene definition (2)	Chromosomal localization	GDB accession ID (3)	LocusLink accession ID (3)
IGLV	IGLV8/OR8-1	ORF, P	Y08831	–	Immunoglobulin lambda variable 8/OR8-1	8q11.2	GDB:9953795	28756
	IGLV/OR8-2			–	Immunoglobulin lambda variable /OR8-2 (provisional)	8q11.2		

b On chromosome 22

IMGT gene group	IMGT gene name (1)	IMGT func-tionality	IMGT reference sequence accession numbers	Number of alleles	IMGT gene definition (2)	Chromosomal localization	GDB accession ID (3)	LocusLink accession ID (3)
IGLC	IGLC/OR22-1		AL008723	–	Immunoglobulin lambda constant /OR22-1	22q12.2-22q12.3	GDB:9991233	84096
	IGLC/OR22-2		AL021937	–	Immunoglobulin lambda constant /OR22-2	22q12.2-22q12.3	GDB:9991234	84086
	IGLV(IV)/OR22-1		AL008721	–	Immunoglobulin lambda variable (IV)/OR22-1	22q11.2-22q12.1	GDB:9991235	84088
	IGLV(IV)/OR22-2		AL021937	–	Immunoglobulin lambda variable (IV)/OR22-2	22q12.2-22q12.3	GDB:9991236	84087

c Not localized
Another orphon has been identified but not yet sequenced

IMGT gene group	IMGT gene name (1)	IMGT func-tionality	IMGT reference sequence accession numbers	Number of alleles	IMGT gene definition (2)	Chromosomal localization	GDB accession ID (3)	LocusLink accession ID (3)
IGLV	IGLV8/OR2			–	Immunoglobulin lambda variable 8/OR2 (provisional)	unknown		

(1) Note that in the HUGO symbols, slashes of the orphon names and parentheses are omitted. Otherwise the gene names (gene symbols) are identical in IMGT and HUGO nomenclatures.
(2) Gene definitions (full names) are identical (including slashes and parentheses) in IMGT and HUGO nomenclatures.
(3) Other entries concerning the IGL orphons in the GDB and LocusLink genome databases.

Orphons

Six IGL genes have been found outside the main locus in other chromosomal localizations (table 2). These genes, designated as orphons, cannot contribute to the synthesis of the immunoglobulin lambda chains, even if they have an open reading frame (ORF). Two IGLV orphons have been identified on chromosome 8 at 8q11.2 and one of them belonging to subgroup 8 has been sequenced [38]. Two IGLC orphons and two IGLV orphons have been characterized on 22q outside of the major IGL locus [26] (table 2).

IGL Gene Nomenclature and IMGT Scientific Chart

Gene Names

Gene names (table 1, 2) are designated according to the IMGT gene name nomenclature for Ig and T cell receptors of all vertebrates based on the 'CLASSIFICATION' concept of IMGT-ONTOLOGY [39] (Appendix 1) and according to the rules of the IMGT Scientific chart [20, 22] available at **http://imgt.cines.fr.** IMGT gene names and IMGT gene definitions for the human IG [40] and TR genes [41] were approved by the HUGO Nomenclature Committee in 1999. Note that in the HUGO symbols **(http://www.gene.ucl.ac.uk/nomenclature),** slashes and parentheses are omitted and capital letters replace the lowercase letters found in some provisional IMGT gene names. Otherwise the gene symbols and all the full names (including slashes and parentheses) are identical in IMGT and HUGO nomenclatures.

Functionality

Criteria of functionality (F = functional, P = pseudogene, ORF = open reading frame) (table 1, 2) have been described in the IMGT Scientific chart [1]. The definition of functionality is based on the sequence analysis. As examples, the instances functional (for germline V, D, J, and for C sequences) mean that the coding regions have an ORF without a stop codon, and that there is no described defect in the splicing sites and/or recombination signals and/or regulatory elements. According to the gravity of the identified defects, the functionality can be defined as ORF, pseudogene or vestigial (for germline V, D, J and for C genes) [1]. Complete definitions are available in the IMGT Scientific chart at the IMGT Marie-Paule page. Information on gene rearrangement, DNA transcription into mRNA and RNA translation into a polypeptide chain is provided in the IMGT 'Germline gene tables' in the IMGT Repertoire (columns designated as R, T and Pr, respectively), and has been published in a previous 'IMGT Locus in Focus' report [2]. This information is extracted from the literature and through an IMGT/LIGM-DB sequence database search [21–23]. The IMGT/V-QUEST tool, available at the IMGT Home page at **http://imgt.cines.fr,** allows the identification of the germline IGLV and IGLJ genes from IGLV-J genomic rearrangements and transcripts, and provides translation and two-dimensional representation (Collier de Perles) of the variable regions [21, 22, 42].

Reference Sequences

For each gene, an IMGT reference sequence accession number is given (table 1, 2). For the functional or ORF genes, the IMGT reference sequence accession number is that corresponding to the allele*01. Note that the number *01 does not necessarily mean that other alleles are already known: it signifies that any new polymorphic sequence will be described by comparison to that allele *01. Although the IMGT accession numbers are the same as those from the EMBL/GenBank/

Table 3. Correspondence between the human IGLV nomenclatures. IGLV genes are listed from 3′ in the IGL locus (top of the table) to 5′ (bottom of the table)

IMGT, IGLV gene name [2, 19]	Frippiat et al. [27] Williams, Frippiat et al. [29]	Kawasaki et al. [30]	IMGT, IGLV gene name [2, 19]	Frippiat et al. [27] Williams, Frippiat et al. [29]	Kawasaki et al. [30]
3-1	3r	2-1	1-36	1a	1-11
3-2	3q	2-2P	5-37	5e	4-1
4-3	4c	5-1	(I)-38		1-12P
3-4		2-3P	5-39	5a	
2-5	2a1	1-1P	1-40	1e	1-13
3-6	3a2	2-4P	1-41	1d	1-14P
3-7	3n	2-5P	(VII)-41-1	lambdavgl	
2-8	2c	1-2	(I)-42	V lambda A	1-15P
3-9	3j	2-6	7-43	7a	3-2
3-10	3p	2-7	1-44	1c	1-16
2-11	2e	1-3	5-45	5c	4-2
3-12	3i	2-8	7-46	7b	3-3
3-13	3f	2-9P	1-47	1g	1-17
2-14	2a2	1-4	5-48	5d	4-3
3-15		2-10P	9-49	9a	5-2
3-16	3a	2-11	1-50	1f	1-18
3-17	3g	2-12P	1-51	1b	1-19
2-18	2d	1-5	5-52	5b	4-4
3-19	3l	2-13	(IV)-53		4-5P
(I)-20		1-6P	10-54	10a	1-20
3-21	3h	2-14	11-55		4-6
3-22	3e	2-15	(I)-56		1-21P
(VI)-22-1	lambdavg2		6-57	6a	1-22P
2-23	2b2	1-7	(V)-58		5-3P
3-24	3d	2-16P	(IV)-59		4-7P
3-25	3m	2-17	4-60	4a	5-4
(VI)-25-1	lambdavg3		8-61	8a	3-4
3-26	3b	2-18P	1-62		1-23P
3-27		2-19	(I)-63		1-24P
2-28	2b1	1-8P	(IV)-64		4-8P
3-29	3c	2-20P	(IV)-65		4-9P
3-30	3o	2-21P	(V)-66		5-5P
3-31	3k	2-22P	(IV)-66-1		
3-32	3i1	2-23P	10-67	10b	1-25P
2-33	2f	1-9	(I)-68		1-26P
2-34		1-10P	4-69	4b	5-6
7-35	7c	3-1P	(I)-70		1-27P

DDBJ generalist databases, the content of the IMGT/LIGM-DB flat files differs in terms of the expert annotations added by IMGT.

Alleles

The number of alleles of the human IGLV, IGLJ and IGLC genes (table 1, 2) is determined according to 'Tables of alleles' and 'Alignments of alleles', in the IMGT Repertoire, at **http://imgt.cines.fr.** A dash (–) indicates that allele polymorphism of the pseudogenes has not been studied. Alignments of all known germline functional and ORF sequences assigned to the different alleles, by comparison to the allele *01, are displayed in another source [19]. Human IGL entries in

this source include 53 genes and 108 alleles, with a total of 213 sequences [19].

Genome Database Accession Numbers

All IMGT/HUGO human IGL gene symbols, full names and reference sequence accession numbers have been entered into the Genome Database GDB, Toronto, Canada **(http://www.gdb.org)**, and into LocusLink at NCBI (National Center for Biotechnology Information), Bethesda, Md., USA **(http://www.ncbi.nlm.nih.gov/LocusLink)**. Accession ID to these genome databases are provided in table 1 and 2. Links to OMIM (Online Mendelian Inheritance in Man, MIM) **(http://www.ncbi.nlm.nih.gov/Omim)** are cited when there are existing entries in OMIM. Links to the individual IMGT, GDB and LocusLink gene entries are available from **http://imgt.cines.fr** from IMGT Repertoire > Lists of IG and TR.

Correspondences between Nomenclatures and Numberings

Correspondence between the human IGLV gene nomenclatures is reported in table 3.

In order to be able to easily compare sequences of immunoglobulins and T cell receptors, a unique numbering has been defined for the variable regions [42, 43]. Correspondence between the IMGT unique numbering and other numberings for the human IGLV genes is available from the IMGT Scientific chart and a previous report [42]. The IMGT unique numbering relies on the high conservation of the structure of the variable region. This numbering takes into account and combines the definition of the framework (FR) and complementarity determining regions (CDR) [44], structural data from X-ray diffraction studies [45], and the characterization of the hypervariable loops [46]. The unique numbering has allowed the redefinition of the limits of the FR and CDR [42]. The FR-IMGT and CDR-IMGT lengths themselves become crucial information characterizing the variable regions belonging to a group, a subgroup, and/or a gene. For example, for a germline gene of the human IGLV2 subgroup, the lengths of the 3 CDR-IMGT, expressed as the number of amino acids, are designated as [9.3.9] (IMGT Repertoire>2D and 3D structures) [7, 42]. The unique numbering is used as the output of the IMGT/V-QUEST alignment tool, and in the 'Alignments of alleles' (IMGT Repertoire>Proteins and alleles) [19].

Acknowledgments

I thank Gérard Lefranc, Ruth Lovering, Donna Maglott, Chris Porter, Sue Povey, Conover Talbot and all my immunologist colleagues for their contribution to the IMGT Nomenclature Committee. I am grateful to Valérie Contet for the editorial work. IMGT is funded by the European Union's 5th PCRDT (QLG2-2000-01287) program, the Centre National de la Recherche Scientifique, the Ministère de la Recherche and the Ministère de l'Education Nationale. Subventions have been received from Association pour la Recherche sur le Cancer and the Région Languedoc-Roussillon.

Appendix 1

The 'CLASSIFICATION' Concept of IMGT-ONTOLOGY

The 'CLASSIFICATION' concept of IMGT-ONTOLOGY (fig. 3) organizes the immunogenetic knowledge that is useful for the naming and classification of the immunoglobulin genes [39].

'Locus': A locus is a group of immunoglobulin genes that are ordered and localized in the same chromosomal location in a given species. The IGL 'locus' (22q11.2) is one of the three main immunoglobulin loci in the human genome. Immunoglobulin genes have also been identified in other chromosomal locations outside the main loci, which represent new

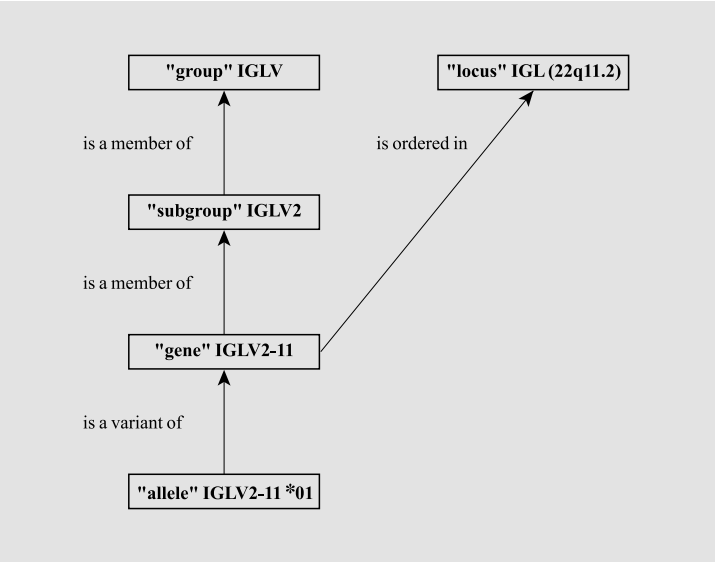

Fig. 3. The 'CLASSIFICATION' concept of IMGT-ONTOLOGY, exemplified for the IGLV genes.

instances of the locus concept. However, the genes they contain, designated as 'orphons', are not functional.

'Group': A group is a set of genes which share the same 'gene type' (V, D, J or C) and potentially participate in the synthesis of a polypeptide of the same 'chain type'. By extension, a group includes the related pseudogenes and orphons. A 4-letter root designates the 'group', for example, IGLV, IGLJ, and IGLC for the immunoglobulin lambda genes.

'Subgroup': A subgroup is a set of genes which belong to the same group, in a given species, and which share at least 75% identity at the nucleotide level (in the germline configuration for V, D, and J). For example, the IGLV genes belong to 11 subgroups.

'Gene': A gene is defined as a DNA sequence that can be potentially transcribed and/or translated (this definition includes the regulatory elements in 5′ and 3′, and the introns, if present). Instances of the 'gene' concept are gene names. By extension, orphons and pseudogenes are also instances of the 'gene' concept. For each gene, IMGT has defined a reference sequence [20]. For the V, D, and J genes, the reference sequence corresponds to a germline entity. The rules for the choice of the reference sequences are described at **http://imgt.cines.fr:8104** in the IMGT Scientific chart.

'Allele': An allele is a polymorphic variant of a gene. Alleles are described, exhaustively and in a standardized way, for the four 'core' coding regions, that is for the germline V-REGIONs, D-REGIONs and J-REGIONs and for the C-REGIONs of immunoglobulin genes. These alleles refer to sequence polymorphisms, with mutations described at the sequence level [1]. Their sequences are compared to the reference sequence designated as *01 (see IMGT Scientific chart at **http://imgt.cines.fr:8104** for IMGT description of mutations and IMGT allele nomenclature for sequence polymorphisms).

References

1 Lefranc MP: IMGT (ImMunoGeneTics) Locus on Focus. A new section of *Experimental and Clinical Immunogenetics.* Exp Clin Immunogenet 1998;15:1–7.

2 Pallarès N, Frippiat JP, Giudicelli V, Lefranc MP: The human immunoglobulin lambda variable (IGLV) genes and joining (IGLJ) segments. Exp Clin Immunogenet 1998;15:8–18.

3 Barbié V, Lefranc MP: The human immunoglobulin kappa variable (IGKV) genes and joining (IGKJ) segments. Exp Clin Immunogenet 1998;15:171–183.

4 Martinez C, Lefranc MP: The mouse *(Mus musculus)* immunoglobulin kappa variable (IGKV) genes and joining (IGKJ) segments. Exp Clin Immunogenet 1998;15: 184–193.

5 Pallarès N, Lefebvre S, Contet V, Matsuda F, Lefranc MP: The human immunoglobulin heavy variable (IGHV) genes. Exp Clin Immunogenet 1999;16:36–60.

6 Ruiz M, Pallarès N, Contet V, Barbié V, Lefranc MP: The human immunoglobulin heavy diversity (IGHD) and joining (IGHJ) segments. Exp Clin Immunogenet 1999;16:173–184.

7 Scaviner D, Barbié V, Ruiz M, Lefranc MP: Protein displays of the human immunoglobulin heavy, kappa and lambda variable and joining regions. Exp Clin Immunogenet 1999;16:234–240.

8 Folch G, Lefranc MP: The human T cell receptor beta variable (TRBV) genes. Exp Clin Immunogenet 2000; 17:42–54.

9 Scaviner D, Lefranc MP: The human T cell receptor alpha variable (TRAV) genes. Exp Clin Immunogenet 2000;17:83–96.

10 Scaviner D, Lefranc MP: The human T cell receptor alpha joining (TRAJ) genes. Exp Clin Immunogenet 2000;17:97–106.

11 Folch G, Lefranc MP: The human T cell receptor beta diversity (TRBD) and beta joining (TRBJ) genes. Exp Clin Immunogenet 2000;17:107–114.

12 Artero S, Lefranc MP: The Teleostei immunoglobulin heavy IGH genes. Exp Clin Immunogenet 2000;17: 148–161.

13 Artero S, Lefranc MP: The Teleostei immunoglobulin light IGL1 and IGL2 V, J and C genes. Exp Clin Immunogenet 2000;17:162–172.

14 Folch G, Scaviner D, Contet V, Lefranc MP: Protein displays of the human T cell receptor alpha, beta, gamma and delta variable and joining regions. Exp Clin Immunogenet 2000;17:205–215.

15 Bosc N, Lefranc MP: The mouse *(Mus musculus)* T cell receptor beta variable (TRBV), diversity (TRBD), and joining (TRBJ) genes. Exp Clin Immunogenet 2000;17:216–228.

16 Bosc N, Contet V, Lefranc MP: The mouse *(Mus musculus)* T cell receptor delta variable (TRDV), diversity (TRDD), and joining (TRDJ) genes. Exp Clin Immunogenet 2001;18: 51–58.

17 Lefranc MP: Nomenclature of the human immunoglobulin heavy (IGH) genes. Exp Clin Immunogenet 2001;18:100–116.

18 Lefranc MP: Nomenclature of the human immunoglobulin kappa (IGK) genes. Exp Clin Immunogenet 2001;18:161–174.

19 Lefranc MP, Lefranc, G: The Immunoglobulin Facts Book. London, Academic Press, 2001, pp 1–458.

20 Lefranc MP, Giudicelli V, Ginestoux C, Bodmer J, Müller W, Bontrop R, Lemaître M, Malik A, Barbié V, Chaume D: IMGT, the international ImMunoGeneTics database. Nucleic Acids Res 1999;27: 209–212.

21 Ruiz M, Giudicelli V, Ginestoux C, Stoehr P, Robinson J, Bödmer J, Marsh S, Bontrop R, Lemaître M, Lefranc G, Chaume D, Lefranc MP: IMGT, the international ImMunoGeneTics database. Nucleic Acids Res 2000;28:219–221.

22 Lefranc MP: IMGT ImMunoGeneTics database. International BIOforum 2000;4:98–100.

23 Lefranc MP: IMGT, the international ImMunoGeneTics database. Nucleic Acids Res 2001;29:207–209.

24 Erikson J, Martinis J, Croce CM: Assignment of the genes for human lambda immunoglobulin chains to chromosome 22. Nature 1981;294: 173–175.

25 Emanuel BS, Cannizzaro LA, Magrath I, Tsujimoto Y, Nowell PC, Croce CM: Chromosomal orientation of the lambda light chain locus: V lambda proximal to C lambda in 22q11. Nucleic Acids Res 1985;13: 381–387.

26 Dunham I, Shimizu N, Roe BA, Chissoe S, Hunt AR, Collins JE, Bruskiewich R, Beare DM, Clamp M, Smink LJ, Ainscough R, Almeida JP, Babbage A, Bagguley C, Bailey J, Barlow K, Bates KN, Beasley O, Bird CP, Blakey S, Bridgeman AM, Buck D, Burgess J, Burrill WD, O'Brien KP, et al: The DNA sequence of human chromosome 22. Nature 1999;402:489–495.

27 Frippiat JP, Williams SC, Tomlinson IM, Cook GP, Cherif D, Le Paslier D, Collins JE, Dunham I, Winter G, Lefranc MP: Organization of the human immunoglobulin lambda light-chain locus on chromosome 22q11.2. Hum Mol Genet 1995;4: 983–991.

28 Kawasaki K, Minoshima S, Schooler K, Kudoh J, Asakaw S, de Jong PJ, Shimizu N: The organization of the human immunoglobulin lambda gene locus. Genome Res 1995;5: 125–135.

29 Williams SC, Frippiat JP, Tomlinson IM, Ignatovich O, Lefranc MP, Winter G: Sequence and evolution of the human germline V lambda repertoire. J Mol Biol 1996;264: 220–232.

30 Kawasaki K, Minoshima S, Nakato E, Shibuya K, Shintani A, Schmeits JL, Wang J, Shimizu N: One-megabase sequence analysis of the human immunoglobulin lambda gene locus. Genome Res 1997;7:250–261.

31 Hieter PA, Hollis GF, Korsmeyer SJ, Waldmann TA, Leder P: Clustered arrangement of immunoglobulin lambda constant region genes in man. Nature 1981;294:536–540.

32 Taub RA, Hollis GF, Hieter PA, Korsmeyer SJ, Waldmann TA, Leder P: Variable amplification of immunoglobulin lambda light-chain genes in human populations. Nature 1983;304:172–174.
33 Dariavach P, Lefranc G, Lefranc MP: Human immunoglobulin C lambda 6 gene encodes the Kern+Oz-lambda chain and C lambda 4 and C lambda 5 are pseudogenes. Proc Natl Acad Sci USA 1987;84:9074–9078.
34 Vasicek TJ, Leder P: Structure and expression of the human immunoglobulin lambda genes. J Exp Med 1990;172:609–620.
35 Ghanem N, Dariavach P, Bensmana M, Chibani J, Lefranc G, Lefranc MP: Polymorphism of immunoglobulin lambda constant region genes in populations from France, Lebanon and Tunisia. Exp Clin Immunogenet 1988;5:186–195.
36 Kay PH, Moriuchi J, Ma PJ, Saueracher E: An unusual allelic from of the immunoglobulin lambda constant region genes in the Japanese. Immunogenetics 1992;35:341–343.
37 Lefranc MP, Pallarès N, Frippiat JP: Allelic polymorphisms and RFLP in the human immunoglobulin lambda light chain locus. Hum Genet 1999;104:361–369.
38 Frippiat JP, Dard P, Marsh S, Winter G, Lefranc MP: Immunoglobulin lambda light chain orphons on human chromosome 8q11.2. Eur J Immunol 1997;27:1260–1265.
39 Giudicelli V, Lefranc MP: Ontology for immunogenetics: IMGT-ONTOLOGY. Bioinformatics 1999;12:1047–1054.
40 Lefranc MP: Nomenclature of the human immunoglobulin genes. Curr Protocols Immunol 2000;A.1P.1-A.1P.37.
41 Lefranc MP: Nomenclature of the human T cell Receptor genes. Curr Protocols Immunol 2000;A.1O.1-A.1O.23.
42 Lefranc MP: The IMGT unique numbering for Immunoglobulins, T cell receptors and Ig-like domains. Immunologist 1999;7:132–136.
43 Lefranc MP: Unique database numbering system for immunogenetic analysis. Immunol Today 1997;8:509.
44 Kabat EA, Wu TT, Reid-Miller M, Perry HM, Gottesman KS: Sequences of Proteins of Immunological Interest, ed 4. Washington, Public Health Service 1987.
45 Satow Y, Cohen GH, Padlan EA, Davies DR: Phosphocholine binding immunoglobulin Fab McPC603. An X-ray diffraction study at 2.7 A. J Mol Biol 1986;190:593–604.
46 Chothia C, Lesk AM: Canonical structures for the hypervariable regions of immunoglobulins. J Mol Biol 1987;196:901–917.