
The Human Immunoglobulin Heavy Diversity (IGHD) and Joining (IGHJ) Segments

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Key Words

Human · IMGT · Immunoglobulin · Heavy

Abstract

The 'Human Immunoglobulin Heavy Diversity (IGHD) and Joining (IGHJ) segments', fifth report of the 'IMGT Locus on Focus' section, comprises six tables entitled: (1) 'Human germlineIGHD segments at 14q32.33'; (2) 'HumanIGHD alleles'; (3) 'Human germlineIGHJ segments at 14q32.33'; (4) 'HumanIGHJ alleles'; (5) 'Human germlineIGHD orphons on chromosome 15 (15q11.2)'; (6) 'Correspondence between the different humanIGHD nomenclatures', and two figures: (1) 'Protein display of humanIGH D-REGIONS'; (2) 'Protein display of humanIGH J-REGIONS'. These tables and figures are available at the IMGT Marie-Paule page from **IMGT**, the international ImMunoGeneTics database (<http://imgt.cnusc.fr:8104>) created by Marie-Paule Lefranc, Université Montpellier II, CNRS, France.

Introduction

'Human Immunoglobulin Heavy Diversity (IGHD) and Joining (IGHJ) segments' is the fifth report of the 'IMGT Locus on Focus' section launched in the April 1998 issue of *Experimental and Clinical Immunogenetics* [1], with the first report on the human IGLV genes and IGLJ segments [2], the second report on human IGKV genes and IGKJ segments [3], the third report on mouse (*Mus musculus*) IGKV genes and IGKJ segments [4] and the fourth report on human IGHV genes [5].

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0254-9670/99/0163-0173\$17.50/0

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Table 1

Human germline IGHD segments at 14q32.33

Fct: FUNCTIONALITY

F : Functional

ORF : Open Reading Frame

IGHD subgroup	IGHD name	Fct	Reference sequences	Accession numbers	Position in X97051 (a)	Position in X97051 (b)	Sequences from the literature
1	1-1	F	D1-1	X97051 [8]	23599-35048	33686-33758	M4 [9]
	1-7	F	DM1	X13972 [5]	43057-44649	43272-43344	M37277 [5], D1-7 [X97051][8]
	1-14	ORF	DM2	X13972 [5]	52325-53909	52540-52612	M37277 [5], D1-14 [X97051][8]
	1-20	F	D1-20	X97051 [8]	61770-63337	61987-62059	M3 [9]
	1-26	F	D1-26	X97051 [8]	71927-79765	72141-72216	M3 [9]
	2-2	F	D4	J00232 [1]			LR4 [9]
2		F	D2-2	X97051 [8]	35049-37615	36339-36425	
		F	D4	M35648 [3]			M35649 [3]
	2-8	F	DLR1	X13972 [5]	44650-47262	45954-46040	M37277 [5], D2-8 [X97051][8], M35650 [3]
	2-15	F	D2	J00234 [1]	53910-56408	55207-55293	D2-15 [X97051][8], LR2 [9]
	2-21	F	D3	J00235 [1]			LR3 [9]
	3-3	F	D2-21	X97051 [8]	63338-65916	64616-64699	
3		F	DXP4	X13972 [5]	37616-39425	38806-38892	M37277 [5], D3-3 [X97051][8]
		F	D23/7	X93618 [4]			
	3-9	F	DXP1	X13972 [5]	47263-48619	48484-48570	M37277 [5], M37485 [7], D21/0.5 [X93613][4], D3-9 [X97051][8]
	3-10	F	DXP1	X13972 [5]	48620-49158	48668-48754	M37277 [5], M37485 [7], D3-10 [X97051][8]
		F	D21/7	X93615 [4]			
	3-16	F	D21/10	X93614 [4]	56409-58143	57524-57616	D3-16 [X97051][8] (1), XP2 [9]
4	3-22	F	D21/9	X93616 [4]	65917-67762	67133-67219	D3-22 [X97051][8], XP3 [9]
	4-4	F	DA4	X13972 [5]	39426-40474	39958-40029	M37277 [5], D4-4 [X97051][8]
	4-11	ORF	DA1	X13972 [5]	49159-50078	49563-49634	M37277 [5] (2), D4-11 [X97051][8]
	4-17	F	D4-17	X97051 [8]	58144-59187	58671-58742	A2 [9]
	4-23	ORF	D4-23	X97051 [8]	67763-68826	68306-68380	A3 [9]
	5-5	F	DK4	X13972 [5]	40475-41880	40919-40994	M37277 [5], D5-5 [X97051][8]
5	5-12	F	DK1	X13972 [5]	50079-51316	50523-50601	M37277 [5], D5-12 [X97051][8]
	5-18	F	D5-18	X97051 [8]	59188-60591	59633-59708	K2 [9]
	5-24	ORF	D5-24	X97051 [8]	68827-70492	69272-69347	K3 [9]

6	6-6	F	DN4	X13972 [5]	41881-43056	42767-42840	M37277 [5], D6-6 [X97051][8]
	6-13	F	DN1	X13972 [5]	52032-52108	M37277 [5], D6-13 [X97051][8]	
	6-19	F	D6-19	X97051 [8]	60592-61769	N2 [9]	
	6-25	F	D6-25	X97051 [8]	70493-71926	N3 [9]	
7	7-27	F	DHQ52	J00256 [2]	87428-87515	87431-87497	D7-27 [X97051][8], X86355 [6], X86356 [6], X86357 [6], X86358 [6], X86359 [6]

(a) Arbitrary limits of the DNA sequence assigned to the different D-SEGMENTS

(b) Limits from the 5'D-NONAMER to the 3'D-NONAMER

Notes

- (1) The g29>c and c30>g substitutions in X97051 EMBL flat file are probably typing errors.
- (2) The deletion of one nucleotide (t) in M37277 EMBL flat file is probably a typing error. This deletion does not exist in the paper.

References

- [1] Siebenlist, U. et al., Nature, 294: 631-635 (1981)
- [2] Ravetch, J.V. et al., Cell, 27: 583-591 (1981)
- [3] Zong, S.Q. et al., Immunol.Lett., 17: 329-334 (1988)
- [4] Buluwela, L. et al., EMBO J., 7: 2003-2010 (1988)
- [5] Ichihara, Y. et al., EMBO J., 7: 4141-4150 (1988)
- [6] Mattiia, P.S. et al., Eur.J.Immunol., 25: 2578-2582 (1995)
- [7] Huang, C. et al., Unpublished
- [8] Corbett, S. Unpublished
- [9] Matsuda, F. et al., J.Exp.Med., 188: 2152-2162 (1998). Accession number AB019441 is not yet available (March 99).

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Last Updated: 15/12/98

Table 2**Human IGHD alleles**

Fct : FUNCTIONALITY

F : Functional

ORF : Open Reading Frame

D-REGION alleles are only described at the nucleotide level since D-REGION can be used in the three reading frames. The numbering starts with the first nucleotide following the heptamer.

The accession number of a reference sequence is given for each allele.

IGHD subgroup	IGHD name	Fct	IGHD allele name	Accession number	confirmed by genetics and/or data	Description of mutations
1	1-1	F	D1-1*01	X97051		
	1-7	F	D1-7*01	X13972	+	
	1-14	ORF	D1-14*01	X13972	+	
	1-20	F	D1-20*01	X97051		
	1-26	F	D1-26*01	X97051		
2	2-2	F	D2-2*01	J00232		a1 g29
		F	D2-2*02	X97051		g29>a
		F	D2-2*03	M35648	+	a1>t
	2-8	F	D2-8*01	X13972	+	a14 a15
		F	D2-8*02	J00233		a14>g a15>g
	2-15	F	D2-15*01	J00234	+	
	2-21	F	D2-21*01	J00235	+	t19
F		D2-21*02	X97051		t19>c	
3	3-3	F	D3-3*01	X13972	+	c7 g8
		F	D3-3*02	X93618		c7>g g8>c
	3-9	F	D3-9*01	X13972	+	
	3-10	F	D3-10*01	X13972	+	g12
		F	D3-10*02	X93615		g12>del
	3-16	F	D3-16*01	X93614	+	
3-22	F	D3-22*01	X93616	+		
4	4-4	F	D4-4*01	X13972	+	
	4-11	ORF	D4-11*01	X13972	+	
	4-17	F	D4-17*01	X97051		
	4-23	ORF	D4-23*01	X97051		
5	5-5	F	D5-5*01	X13972	+	
	5-12	F	D5-12*01	X13972	+	
	5-18	F	D5-18*01	X97051		
	5-24	ORF	D5-24*01	X97051		
6	6-6	F	D6-6*01	X13972	+	
	6-13	F	D6-13*01	X13972	+	
	6-19	F	D6-19*01	X97051		
	6-25	F	D6-25*01	X97051		
7	7-27	F	D7-27*01	J00256	+	

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Last Updated : 26/11/98

Table 3

Human germline IGJH segments at 14q32.33

Fct : FUNCTIONALITY

F : Functional

P : Pseudogene

IGHJ name	Fct	Reference sequences	Accession numbers	Sequences from the literature
IGHJ1P	P	J1P	J00256 1	X86355/X86356/X86357/X86358/X86359 [3](2), X97051 [4]
IGHJ1	F	J1	J00256 1	X86355/X86356/X86357/X86358/X86359 [3](2), X97051 [4]
IGHJ2	F	J2	J00256 1	X86355/X86356/X86357/X86358/X86359 [3](2), X97051 [4]
IGHJ2P	P	J2P	J00256 1	X86355/X86356/X86357/X86358/X86359 [3](2), X97051 [4]
IGHJ3	F	J3	J00256 1	M25625 [2]
	F		X86355/X86356/X86357/X86358/X86359 [3](2)	X97051 [4]
IGHJ4	F	J4	J00256 1	
	F		X86355/X86356/X86357/X86358/X86359 [3](2)	X97051 [4]
	F		M25625 [2](5)	
IGHJ5	F	J5	J00256 1	M25625 [2]
	F		X86355/X86356/X86357/X86358/X86359 [3](2)	X97051 [4]
IGHJ3P	P	J3P	J00256 1	M25625 [2]
	P		X86355/X86356/X86357/X86358/X86359 [3](2)	X97051 [4]
IGHJ6	F	J6	J00256 1	
	F		X86355/X86357/X86358 3	X97051 [4], M63031 [5], M25625 [2](5)
	F		X86356/X86359 [3](4)	M63030 [5]

Notes

Haplotypes have been described in Mattila et al., Eur. J. Immunol., 25, 2578-2582 (1995) [1] Ravetch et al., Cell, 27, 583-591 (1981)

- (1) sequenced in haplotype a.
- (2) sequenced in haplotypes b1, b1c, b2, b3 and c, respectively.
- (3) sequenced in haplotypes b1, b2 and b3, respectively.
- (4) sequenced in haplotypes b1c and c, respectively.
- (5) sequenced in haplotype d.

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Last Updated: 08/10/97

References

- [2] Rabbitts, Biochem. Soc. Trans., 11, 119-126 (1983)
- [3] Mattila et al., Eur. J. Immunol., 25, 2578-2582 (1995)
- [4] Corbett. Unpublished.
- [5] Nottembourg and Hasenstab. Unpublished.

Table 4**Human IGHJ alleles**

Fct : FUNCTIONALITY

F : Functional

The accession number of a reference sequence is given for each allele.

IMGT numbering and description of alleles for germline J-REGIONS start with the first nucleotide of the first codon.

IGHJ name	Fct	IGHJ Allele name	Accession number	confirmed by genetics and/or data	Description of mutations
IGHJ1	F	J1*01	J00256	+	
IGHJ2	F	J2*01	J00256	+	
IGHJ3	F	J3*01	J00256	+	g10 , V4
	F	J3*02	X86355	+	g10>a, V4>I
IGHJ4	F	J4*01	J00256		a21 a24
	F	J4*02	X86355	+	a21>g
	F	J4*03	M25625		a24>g
IGHJ5	F	J5*01	J00256	+	t13 , S5 a24
	F	J5*02	X86355	+	t13>c, S5>P a24>g
IGHJ6	F	J6*01	J00256		g16 , g17 , t18 , G6 g33 c34 , Q12
	F	J6*02	X86355	+	g33>c
	F	J6*03	X86356	+	g16>t, g17>a, t18>c, G6>Y g33>c c34>a, Q12>K

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Last Updated : 08/10/97

This report completes the tables of the immunoglobulin germline genes in humans and comprises six tables entitled:

- (1) 'Human germline IGHD segments at 14q32.33';
- (2) 'Human IGHD alleles';
- (3) 'Human germline IGHJ segments at 14q32.33';
- (4) 'Human IGHJ alleles';
- (5) 'Human germline IGHD orphans on chromosome 15 (15q11.2)';
- (6) 'Correspondence between the different human IGHD nomenclatures',

and two figures:

- (1) 'Protein display of human IGH D-REGIONS';
- (2) 'Protein display of human IGH J-REGIONS'.

Table 5**Human germline IGHD orphans on chromosome 15 (15q11.2)**

Fct : FUNCTIONALITY

ORF : Open Reading Frame

IGHD subgroup	IGHD name	Fct	Reference sequences	Accession numbers	Sequences from the literature
1	1/OR15-1a	ORF	DM5-a	X55575 [3]	
	1/OR15-1b	ORF	DM5-b	X55576 [3]	
2	2/OR15-2a	ORF	D5-a	X55577 [3]	M35647 [1]
	2/OR15-2b	ORF	D5-b	X55578 [3]	M35647 [1]
3	3/OR15-3a	ORF	DXP5-a	X55579 [3]	D22/12 [X93617][2]
	3/OR15-3b	ORF	DXP5-b	X55580 [3]	D22/12 [X93617][2]
4	4/OR15-4a	ORF	DA5-a	X55581 [3]	
	4/OR15-4b	ORF	DA5-b	X55582 [3]	
5	5/OR15-5a	ORF	DK5-a	X55583 [3]	
	5/OR15-5b	ORF	DK5-b	X55584 [3]	

References

- [1] Zong, S.Q. et al., Immunol. Lett., 17: 329-334 (1988)
 [2] Buluwela, L. et al., EMBO J., 7: 2003-2010 (1988)
 [3] Matsuda, F. et al., EMBO J., 9: 2501-2506 (1990)

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Last Updated: 16/04/97

These tables and figures are available at the IMGT Marie-Paule page from **IMGT**, the international ImMunoGeneTics database (<http://imgt.cnusc.fr:8104>) created by Marie-Paule Lefranc, Université Montpellier II, CNRS, France [6–8].

Description of functionality (FUNCTIONAL, ORF, PSEUDOGENE) and description of mutations [1] are according to the IMGT scientific chart available at the IMGT Marie-Paule page [8].

Table 6**Correspondence between the different human IGHD nomenclatures**

IGHD segments are listed from 5' (top of the table) to 3' (bottom of the table).

IMGT IGHD name	Other designations from the literature	
1-1		M4 [5]
2-2	D4 [1]	LR4 [5]
3-3	23/7 [3]	XP4 [4]
4-4		A4 [4]
5-5		K4 [4]
6-6		N4 [4]
1-7		M1 [4]
2-8	D1 [1]	LR1 [4]
3-9	21/0,5 [3]	XP1 [4]
3-10	21/7 [3]	XP'1 [4]
4-11		A1 [4]
5-12		K1 [4]
6-13		N1 [4]
1-14		M2 [4]
2-15	D2 [1]	LR2 [5]
3-16	21/10 [3]	XP2 [5]
4-17		A2 [5]
5-18		K2 [5]
6-19		N2 [5]
1-20		M3 [5]
2-21	D3 [1]	LR3 [5]
3-22	21/9 [3]	XP3 [5]
4-23		A3 [5]
5-24		K3 [5]
6-25		N3 [5]
1-26		M'3 [5]
7-27	DHQ52 [2]	

Note IGH segments are designated by a number for the subgroup followed by a dash and a number for the localisation from 5' to 3' in the locus [6].

References:

- [1] Siebenlist, U. et al., Nature, 294, 631-635 (1981).
- [2] Ravetch, J.V. et al., Cell, 27, 583-591 (1981).
- [3] Buluwela, L. et al., EMBO J., 7, 2003-2010 (1988).
- [4] Ichihara, Y. et al., EMBO J., 7, 4141-4150 (1988).
- [5] Matsuda F. et al., J.Exp.Med., 188, 2151-2162 (1998).
- [6] Corbett, S. Unpublished X97051

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Created: 13/12/98

		Direct 5' - 3' orientation	Inverted orientation
IGHD1-1	X97051,IGHD1-1*01	G T T G T V Q L E R Y N W N D ggtacaactggaacgac	V V P V V S F Q L Y R S S C T gtcgttccagttgtacc
IGHD1-7	X13972,IGHD1-7*01	G I T G T V * L E L Y N W N Y ggtataactggaactac	V V P V I * F Q L Y S S S Y T gtagttccagttatacc
IGHD1-14	X13972,IGHD1-14*01	G I T G T V * P E P Y N R N H ggtataaccggaaccac	V V P V I W F R L Y G S G Y T gtggttccggtatacc
IGHD1-20	X97051,IGHD1-20*01	G I T G T V * L E R Y N W N D ggtataactggaacgac	V V P V I S F Q L Y R S S Y T gtcgttccagttatacc
IGHD1-26	X97051,IGHD1-26*01	G I V G A T V * W E L L Y S G S Y Y ggtatagtgggagctactac	V V A P T I * * L P L Y S S S H Y T gtagtagctcccactatacc
IGHD2-2	J00232,IGHD2-2*01	R I L * * Y Q L L C G Y C S S T S C Y A D I V V V P A A M aggatattgtagtagtaccagctgctatgcc	G I A A G T T T I S A * Q L V L L Q Y P H S S W Y Y Y N I ggcatagcagctggtactactacaatcct
	X97051,IGHD2-2*02	R I L * * Y Q L L <u>Y</u> G Y C S S T S C Y <u>T</u> D I V V V P A A <u>I</u> aggatattgtagtagtaccagctgctatacc	<u>G</u> I A A G T T T I S <u>V</u> * Q L V L L Q Y P <u>Y</u> S S W Y Y Y N I ggtatagcagctggtactactacaatcct
	M35648,IGHD2-2*03	<u>W</u> I L * * Y Q L L C G Y C S S T S C Y A D I V V V P A A M tggatattgtagtagtaccagctgctatgcc	G I A A G T T T I S A * Q L V L L Q Y P H S S W Y Y Y N I ggcatagcagctggtactactacaatcct
IGHD2-8	X13972,IGHD2-8*01	R I L Y * W C M L Y G Y C T N G V C Y T D I V L M V Y A I aggatattgtactaatggtgtatgctatacc	G I A Y T I S T I S V * H T P L V Q Y P Y S I H H * Y N I ggtatagcatacaccattagtacaatcct
	J00233,IGHD2-8*02	R I L Y <u>W</u> W C M L Y G Y C T <u>G</u> G V C Y T D I V L <u>V</u> V Y A I aggatattgtactggtgtatgctatacc	G I A Y T <u>T</u> S T I S V * H T P <u>P</u> V Q Y P Y S I H H <u>Q</u> Y N I ggtatagcatacaccagtcataatcct
IGHD2-15	J00234,IGHD2-15*01	R I L * W W * L L L G Y C S G G S C Y S D I V V V V A A T aggatattgtagtggtagctgctactcc	G V A A T T T T I S E * Q L P P L Q Y P S S S Y H H Y N I ggagtagcagctaccaccatacaatcct
IGHD2-21	J00235,IGHD2-21*01	S I L W W * L L F A Y C G G D C Y S H I V V V I A I agcatattggtggtgattgctattcc	G I A I T T T T I C E * Q S P P Q Y A N S N H H H N M ggaatagcaatcaccaccacaatagct
	X97051,IGHD2-21*02	S I L W W * L L F A Y C G G D C Y S H I V V V <u>T</u> A I agcatattggtggtgactgctattcc	G I A <u>V</u> T T T T I C E * Q <u>S</u> P P Q Y A N S <u>S</u> H H H N M ggaatagcagtcaccaccacaatagct
IGHD3-3	X13972,IGHD3-3*01	V L R F L E W L L Y Y Y D F W S G Y Y T I T I F G V V I I gtattacgatttttggagtggtattatacc	G I I T T P K I V I V * * P L Q K S * Y Y N N H S K N R N ggtataataaccactccaaaatcgtatacc

1a

(For legend 1 see p. 184.)

		Direct 5' - 3' orientation	Inverted orientation
	X93618, IGHD3-3*02	V L <u>A</u> F L E W L L Y Y * <u>H</u> F W S G Y Y T I <u>S</u> I F G V V I I gtattagcatttttgagggttattataacc	G I I T T P K <u>M</u> <u>L</u> I V * * P L Q K <u>C</u> * Y Y N N H S K N <u>A</u> N ggtataataaccactccaaaatgctaataac
	IGHD3-9 X13972, IGHD3-9*01	V L R Y F D W L L * Y Y D I L T G Y Y N I T I F * L V I I gtattacgatattttgactggttattataac	V I I T S Q N I V I L * * P V K I S * Y Y N N Q S K Y R N ggtataataaccagtcacaaatagtaataac
	IGHD3-10 X13972, IGHD3-10*01	V L L W F G E L L * Y Y Y G S G S Y Y N I T M V R G V I I gtattactatggctcgagggttattataac	V I I T P R T I V I L * * L P E P * * Y Y N N S P N H S N ggtataataactccccgaaccatagtaataac
	X93615, IGHD3-10*02	V L L <u>C</u> <u>S</u> <u>G</u> <u>S</u> <u>Y</u> <u>Y</u> <u>N</u> Y Y Y <u>V</u> <u>R</u> <u>G</u> <u>V</u> <u>I</u> <u>I</u> I T M <u>F</u> <u>G</u> <u>E</u> <u>L</u> <u>L</u> <u>*</u> gtattactatg.ttcggggaggttattataac	V I I T P R T * * <u>Y</u> L * * L P E <u>H</u> <u>S</u> <u>N</u> Y N N S P N <u>I</u> <u>V</u> <u>I</u> ggtataataactccccgaac.atagtaataac
	IGHD3-16 X93614, IGHD3-16*01	V L * L R L G E L C L Y Y Y D Y V W G S Y A Y T I M I T F G G V M L I gtattatgatgactgttggggaggttattataacc	G I S I T P P N V I I I V * A * L P Q T * S * Y Y K H N S P K R N H N ggtataaagcataactcccccaacgtaataataac
	IGHD3-22 X93616, IGHD3-22*01	V L L * * * W L L L Y Y Y D S S G Y Y Y I T M I V V V I T gtattactatgatagtaggttattactac	V V I T T T I I V I * * * P L L S * * Y S N N H Y Y H S N gtagtaataaccactactatcatagtaataac
	IGHD4-4 X13972, IGHD4-4*01	* L Q * L D Y S N Y T T V T tgactacagtaactac	V V T V V * L L * S S Y C S gtagttactgtagtea
	IGHD4-11 X13972, IGHD4-11*01	* L Q * L D Y S N Y T T V T tgactacagtaactac	V V T V V * L L * S S Y C S gtagttactgtagtea
	IGHD4-17 X97051, IGHD4-17*01	* L R * L D Y G D Y T T V T tgactacggtgactac	V V T V V * S P * S S H R S gtagtccaccgtagtea
	IGHD4-23 X97051, IGHD4-23*01	* L R W * L D Y G G N S T T V V T tgactacggtgtaactcc	G V T T V V E L P P * S S Y H R S ggagttaccaccgtagtea
	IGHD5-5 X13972, IGHD5-5*01	V D T A M V W I Q L W L G Y S Y G Y gtggatacagctatggttac	V T I A V S * P * L Y P N H S C I H gtaaccatagctgtatccac
	IGHD5-12 X13972, IGHD5-12*01	V D I V A T I W I * W L R L G Y S G Y D Y gtggataatagtgctacgattac	V I V A T I S * S * P L Y P N R S H Y I H gtaatcgtagccactataatccac
	IGHD5-18 X97051, IGHD5-18*01	V D T A M V W I Q L W L G Y S Y G Y gtggatacagctatggttac	V T I A V S * P * L Y P N H S C I H gtaaccatagctgtatccac
	IGHD5-24 X97051, IGHD5-24*01	V E M A T I * R W L Q L R D G Y N Y gtagagatggctacaattac	V I V A I S * L * P S L Y N C S H L Y gtaattgtagccatctctac

1b

(For legends 1 and 2 see p. 184.)

		Direct 5' - 3' orientation	Inverted orientation
IGHD6-6	X13972,IGHD6-6*01	E Y S S S S S I A A R V * Q L V gagtatagcagctcgtcc	G R A A I L D E L L Y T S C Y T ggaccagctgctatactc
IGHD6-13	X13972,IGHD6-13*01	G Y S S S W Y G I A A A G V * Q Q L V gggtatagcagcagctggtac	V P A A A I P Y Q L L L Y T S C C Y T gtaccagctgctgctataccc
IGHD6-19	X97051,IGHD6-19*01	G Y S S G W Y G I A V A G V * Q W L V gggtatagcagtgctggtac	V P A T A I P Y Q P L L Y T S H C Y T gtaccagcactgctataccc
IGHD6-25	X97051,IGHD6-25*01	G Y S S G Y G I A A A V * Q R L gggtatagcagcggctac	V A A A I P * P L L Y S R C Y T gtaccagctgctataccc
IGHD7-27	J00256,IGHD7-27*01	L T G * L G N W G ctaactgggga	S P V P Q L P S * tccccagttag

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1c

IGHJ1*01		A E Y F Q H W G Q G T L V T V S S GCT GAA TAC TTC CAG CAC TGG GGC CAG GGC ACC CTG GTC ACC GTC TCC TCA G
IGHJ2*01		Y W Y F D L W G R G T L V T V S S C TAC TGG TAC TTC GAT CTC TGG GGC CGT GGC ACC CTG GTC ACT GTC TCC TCA G
IGHJ3*01		A F D V W G Q G T M V T V S S AT GCT TTT GAT GTC TGG GGC CAA GGG ACA ATG GTC ACC GTC TCT TCA G
IGHJ3*02		--- -- A-- --- --- --- --- --- --- --- --- ---
IGHJ4*01		Y F D Y W G Q G T L V T V S S AC TAC TTT GAC TAC TGG GGC CAA GGA ACC CTG GTC ACC GTC TCC TCA G
IGHJ4*02		--- --- --- --- --- --- --- --- --- --- --- --- ---
IGHJ4*03		G- --- --- --- --- --- --- --- --- --- --- --- --- ---
IGHJ5*01		N W F D S W G Q G T L V T V S S AC AAC TGG TTC GAC TCC TGG GGC CAA GGA ACC CTG GTC ACC GTC TCC TCA G
IGHJ5*02		--- --- --- --- --- --- --- --- --- --- --- --- ---
IGHJ6*01		Y Y Y Y Y G M D V W G Q G T T V T V S S AT TAC TAC TAC TAC TAC GGT ATG GAC GTC TGG GGC CAA GGG ACC ACG GTC ACC GTC TCC TCA G
IGHJ6*02		--- --- --- --- --- --- --- --- --- --- --- --- ---
IGHJ6*03		--- --- --- --- --- --- --- --- --- --- --- --- ---

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Acknowledgments

We are grateful to Gérard Lefranc, Johanne Abad, Sylvaine Artéro, Géraldine Folch, Véronique Giudicelli, Christèle Jean, and Dominique Scaviner for helpful discussion. IMGT is funded by the European Union's BIOTECH programme (BIO4CT96-0037), Centre National de la Recherche Scientifique, and the

Ministère de l'Éducation Nationale, de la Recherche et de la Technologie. Subventions have been received from: Association pour la Recherche sur le Cancer, Association de la Recherche sur la Polyarthrite, Fondation pour la Recherche Médicale, Ligue Nationale contre le Cancer, and the Région Languedoc-Roussillon.

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Fig. 1. Protein display of human IGH D-REGIONS. Amino acids are shown with one-letter abbreviations. D-REGIONS are shown in the three reading frames. Some of the D-REGIONS having been found in inverted orientations [9, 10], the IGH D-REGIONS are shown in both direct 5'-3' and inverted orientations.

Fig. 2. Protein display of human IGH J-REGIONS. Amino acids are shown with one-letter abbreviations. The conserved W-G-X-G (Trp-Gly-X-Gly) motif is underlined. Note that the JUNCTIONS of rearranged IGHV-D-J-GENES extend from 2nd-CYS (cysteine 104 of the V-REGION) to J-TRP (conserved Trp of the J-REGION), whereas the CDR3-IMGT extend from amino acid 105 of the V-REGION to J-TRP not included.