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# The Teleostei Immunoglobulin Heavy IGH Genes

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**Key Words**

Teleostei · IMGT · Immunoglobulin · Heavy variable genes · Heavy joining genes · Heavy constant genes

**Abstract**

'Teleostei Immunoglobulin Heavy IGH Genes', the eleventh report of the 'IMGT Locus in Focus' section, comprises four tables: (1) 'Teleostei IGHV genes'; (2) 'Teleostei germline IGHJ genes'; (3) 'Teleostei IGHC genes and alleles'; (4) 'FR-IMGT and CDR-IMGT length of the Teleostei IGHV genes'. These tables are available at the IMGT Marie-Paule page from **IMGT,** the international ImMunoGeneTics database **(http://imgt.cines.fr:8104)** created in 1989 by Marie-Paule Lefranc, Université Montpellier II, CNRS, France.

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## Introduction

'Teleostei Immunoglobulin Heavy IGH Genes' is the 11th report of the 'IMGT Locus in Focus' section launched in the April 1998 issue of *Experimental and Clinical Immunogenetics* [1]. We have previously reported the complete repertoire of the human germline V and J genes of the immunoglobulin IGK and IGL and of the T cell receptor TRA loci [2–6], and that of the human germline V, D and J genes of the immunoglobulin IGH and of the T-cell receptor TRB loci [6–10]. This eleventh report on Teleostei Immunoglobulin Heavy IGH Genes describes the current data for 11 species of teleost fishes whose sequences are found in IMGT/LIGM-DB (fig. 1). It comprises four tables: (1) 'Teleostei IGHV genes'; (2) 'Teleostei germline IGHJ genes'; (3) 'Teleostei IGHC genes and alleles'; (4) 'FR-IMGT and CDR-IMGT length of the Teleostei IGHV genes'. These tables are available at the IMGT Marie-Paule page from **IMGT**, the international ImMunoGeneTics database **(http://imgt.cines.fr:8104)** created in 1989 by Marie-Paule Lefranc, Université Montpellier II, CNRS, France [11, 12]. Teleostei IGH genes have a temporary designation based on the IMGT gene name nomenclature rules for the unmapped genes, the incomplete loci, or the cDNAs in the absence of germline genes. Descriptions of functionality (functional, open reading frame, pseudogene) are according to the IMGT Scientific chart [11, 12], available at the IMGT Marie-Paule page.

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# Table 1. Teleostei IGHV genes

**Fct**: FUNCTIONALITY
**F**: Functional
**P**: Pseudogene
**ORF**: Open Reading Frame
**vg**: Vestigial
**R**: Rearranged
**T**: Transcribed
**Pr**: Translated into protein

"+" or "-" indicates if the gene sequences have been found (+) or not been found (-) rearranged (R), transcribed (T), and/or translated into protein (Pr).
Functionality is shown between parentheses when the accession number refers to a cDNA sequence and the corresponding genomic gene has not yet been isolated.
Except if indicated, there is no correspondence between IGHV subgroups and IGHV gene names between taxons.

| Taxon | IGHV subgroup | IGHV gene name (1) | Fct | R | T | Pr | Reference sequences | Accession numbers | Sequences from the literature |
|---|---|---|---|---|---|---|---|---|---|
| **Antarctic fish (*Trematomus bernacchii*)** | 1 | 1S1 | (F) | + | + |  | 2C2 | AF094531 [8] #c |  |
| **Arctic charr** ***(Salvelinus alpinus)*** (3) | 1 | 1S1 | (F) | + | + |  | cACVH4 | AJ000361 [5] #c |  |
|  |  | 1S2 | (F) | + | + |  | cACVH9 | AJ000367 [5] #c |  |
|  | 2 | 2S1 | (F) | + | + |  | cACVH3 | AJ000360 [5] #c |  |
|  |  | 2S2 | (F) | + | + |  | cACVH27 | AJ000363 [5] #c |  |
|  | 3 | 3S1 | (F) | + | + |  | cACVH124 | AJ000366 [5](2) #c |  |
|  | 4 | 4S1 | (F) | + | + |  | cACVH8 | AJ000368 [5] #c |  |
|  | 5 | 5S1 | (F) | + | + |  | cACVH1 | AJ000359 [5] #c |  |
|  |  | 5S2 | (F) | + | + |  | cACVH2 | AJ000358 [5] #c |  |
|  |  | 5S3 | (F) | + | + |  | cACVH31 | AJ000364 [5] #c |  |
|  | 6 | 6S1 | (F) | + | + |  | cACVH6 | AJ000369 [5] #c |  |
|  |  | 6S2 | (F) | + | + |  | cACVH10 | AJ000370 [5] #c |  |
|  | 8 | 8S1 | (F) | + | + |  | cACVH5 | AJ000362 [5] #c |  |
|  | 11 | 11S1 | (F) | + | + |  | cACVH130 | AJ000365 [5] #c |  |
| **Atlantic cod** ***(Gadhus morhua)*** | 1 | 1S1 | (F) | + | + |  | cSg 5.1 | X58870 [6] #c |  |
|  | 2 | 2S1 | (F) | + | + |  | 112-12 | X76510 [7] #c |  |
|  | 3 | 3S1 | (F) | + | + |  | 112-4 | X76512 [7] #c |  |
|  |  | 3S2 | (F) | + | + |  | 112-22 | X76511 [7] #c |  |
|  |  | 3S3 | (F) | + | + |  | 112-5 | X76514 [7](4) #c |  |
|  |  | 3S4 | (F) | + | + |  | S2A | X76516 [7](5) #c |  |
|  |  | 3S5 | (F) | + | + |  | 101-11 | X76507 [7] #c |  |
|  |  | 3S6 | (F) | + | + |  | 112-25 | X76513 [7] #c |  |
|  |  | 3S7 | (F) | + | + |  | 112-1 | X76509 [7] #c |  |
|  |  | 3S8 | (F) | + | + |  | 3.3 | X76515 [7](6) #c |  |
|  |  | 3S9 | (F) | + | + |  | 101-14 | X76508 [16] #c |  |
| **Atlantic salmon** ***(Salmo salar)*** | 1 | 1S1 | F |  |  |  | g1.1 (10) | Y12452 [10] |  |
|  |  | 1S2 | P(7) |  |  |  | g12.2 (10) | Y12454 [10] |  |
|  |  | 1S3 | P(8) |  |  |  | g11.5 (10) | Y12453 [10] |  |
|  |  | 1S4 | P(9) |  |  |  | g11.5 (10) | Y12455 [10] |  |

**Table 1** (continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Channel catfish**<br>**(Ictalurus punctatus)** | **1** | 1S1 | F | | | | VH1.1 | U09719 [15] | |
| | | 1S2 | (F) | | | | NG70 | M27230 [23] #c | |
| | **2** | 2S1 | P(11) | | | | VH2.1 | U09720 [15] | |
| | | 2S2 | (F) | | | | NG41 | M58671 [24] #c | |
| | **3** | 3S1 | F | | | | VH3.1 | U09721 [15] | |
| | | 3S2 | (F) | | | | NG54 | M58672 [24] #c | |
| | **4** | 4S1 | F | | | | VH4.1 | U09722 [15] | |
| | | 4S2 | (F) | | | | NG10 | M58668 [24] #c | |
| | **5** | 5S1 | P(12) | | | | VH5.1 | U09723 [15] | |
| | | 5S2 | (F) | | | | NG66 | M58674 [24] #c | |
| | **6** | 6S1 | F | | | | VH6.1 | U09724 [15] | |
| | | 6S2 | (F) | | | | | M64400 [25] #c | |
| | **7** | 7S1 | P(13) | | | | VH7.1 | U34412 [16] | |
| | | 7S2 | (F) | | | | cVH7c | U34411 [16] #c | |
| **Fugu**<br>***(Fugu rubripes)*** | **1** | 1S1 | F | | | | F-Vh1 | AF108421 [12] | |
| | | 1S2 | F | | | | F-Vh3 | AF108421 [12] | |
| | | 1S3 | F | | | | F-Vh5 | AF108421 [12] | |
| | | 1S4 | F | | | | F-Vh6 | AF108422 [12] | |
| | | 1S5 | F | | | | F-Vh7 | AF108423 [12] | |
| | **2** | 2S1 | ORF(14) | | | | F-Vh2 | AF108421 [12] | |
| | | 2S2 | ORF(14) | | | | F-Vh4 | AF108421 [12] | |
| | | 2S3 | ORF(14) | | | | F-Vh8 | AF108423 [12] | |
| | | 2S4 | ORF(14) | | | | F-Vh9 | AF108422 [12][15] | |
| **Goldfish**<br>***(Carassius auratus)*** | **1** | 1S1 | F | | | | V3 | J03616 [17][18][16] | |
| | **2** | 2S1 | ORF(17) | | | | 99A | X61312 [19] | |
| | | 2S2 | P(18) | | | | 6X | X65266 [19] | |
| | **3** | 3S1 | P(19) | | | | 99B | X61313 [19] | |
| **Ladyfish**<br>***(Elops saurus)*** | **1** | 1S1 | (F) | + | + | | | M26182 [1] #c | |
| | | 1S2 | P(11) | | | | | M26580 [1] | |
| | | 1S3 | P(8) | | | | | M29586 [1] | |
| | **2** | 2S1 | (F) | + | + | | | M26579 [1] #c | |
| **Rainbow trout**<br>***(Oncorhynchus mykiss)***(20) | **1** | 1S1 | F | | | | RTVH431 | M57442 [11] | |
| | | 1S2 | F | | | | RTVH253 | X92501 [2] | |
| | | 1S3 | (F) | + | + | | cRTVH50 | S63348 [3] #c | |
| | | 1S4 | (F) | + | + | | cRTVH3 | X81490 [4] #c | |
| | | 1S5 | (F) | + | + | | Igh-V4 | L28741 [13] #c | |
| | | 1S6 | (F) | + | + | | TDT255 | X81484 [4] #c | |
| | | 1S7 | (F) | + | + | | cRTVH31 | Y08597 [22] #c | |
| | **2** | 2S1 | (F) | + | + | | cRTVH12 | X81509 [4] #c | |
| | | 2S2 | (F) | + | + | | rts.15S | X65262 [21] #c | |
| | | 2S3 | (F) | + | + | | TDT271 | X81512 [4] #c | |
| | **3** | 3S1 | (F) | + | + | | cRTVH19 | X81510 [4] #c | |
| | | 3S2 | (F) | + | + | | Igh-V5.1 | L28742 [13] #c | |
| | | 3S3 | (F) | + | + | | Igh-V5.2 | L28805 [13] #c | |
| | | 3S4 | (F) | + | + | | cRTVH29 | Y08595 [22] #c | |
| | **4** | 4S1 | (F) | + | + | | Igh-V6 | L28744 [13] #c | |

| Taxon | IGHV subgroup | IGHV gene name (1) | Fct | R | T | Pr | Reference sequences | Accession numbers | Sequences from the literature |
|---|---|---|---|---|---|---|---|---|---|
| | **5** | 5S1 | (F) | + | + | | cRTVH6 | X81513 [4] #c | |
| | | 5S2 | (F) | + | + | | Igh-V7 | L28745 [13] #c | |
| | | 5S3 | (F) | + | + | | RBTIGTM1 | U04616 [20] #c | |
| | | 5S4 | (F) | + | + | | RBTIGTM2 | U04615 [20] #c | |
| | | 5S5 | (F) | + | + | | cRTVH28 | X81493 [4] #c | |
| | | 5S6 | (F) | + | + | | cRTVH25 | X81492 [4] #c | |
| | | 5S7 | (F) | + | + | | cRTVH8 | X81491 [4] #c | |
| | | 5S8 | (F) | + | + | | cRTVH30 | Y08596 [22] #c | |
| | | 5S9 | (F) | + | + | | cRTVH32 | Y08599 [22] #c | |
| | **6** | 6S1 | (F) | + | + | | cRTVH1 | X81481 [4] #c | |
| | | 6S2 | (F) | + | + | | Igh-V8 | L28746 [13] #c | |
| | | 6S3 | (F) | + | + | | cRTVH18 | X81496 [4] #c | |
| | | 6S4 | (F) | + | + | | cRTVH5 | X81494 [4] #c | |
| | | 6S5 | (F) | + | + | | cRTVH23 | X81497 [4] #c | |
| | | 6S6 | (F) | + | + | | cRTVH26 | X81487 [4] #c | |
| | | 6S7 | (F) | + | + | | cRTVH5.1 | X81486 [4] #c | |
| | | 6S8 | (F) | + | + | | cRTVH7 | X81485 [4] #c | |
| | | 6S9 | (F) | + | + | | cRTVH14 | X81495 [4] #c | |
| | | 6S10 | (F) | + | + | | cRTVH33 | Y08600 [22] #c | |
| | | 6S11 | (F) | + | + | | cRTVH37 | Y08602 [22] #c | |
| | **7** | 7S1 | (F) | + | + | | Igh-V9 | L28747 [13] #c | |
| | **8** | 8S1 | (F) | + | + | | cRTVH2 | X81482 [4] #c | |
| | | 8S2 | (F) | + | + | | cRTVH11 | X81501 [4] #c | |
| | | 8S3 | (F) | + | + | | cRTVH24 | X81503 [4] #c | |
| | | 8S4 | (F) | + | + | | cRTVH9 | X81499 [4] #c | |
| | | 8S5 | (F) | + | + | | cRTVH17 | X81488 [4] #c | |
| | | 8S6 | (F) | + | + | | cRTVH15 | X81498 [4] #c | |
| | | 8S7 | (F) | + | + | | cRTVH16 | X81502 [4] #c | |
| | | 8S8 | (F) | + | + | | cRTVH10 | X81500 [4] #c | |
| | | 8S9 | (F) | + | + | | cRTVH2.1 | X81483 [4] #c | |
| | | 8S10 | (F) | + | + | | cRTVH34 | Y08601 [22] #c | |
| | | 8S11 | (F) | + | + | | cRTVH41 | Y08889 [22] #c | |
| | **9** | 9S1 | (F) | + | + | | cRTVH21 | X81505 [4] #c | |
| | | 9S2 | (F) | + | + | | cRTVH20 | X81504 [4] #c | |
| | | 9S3 | (F) | + | + | | cRTVH27 | X81507 [4] #c | |
| | | 9S4 | (F) | + | + | | cRTVH22 | X81506 [4] #c | |
| | | 9S5 | (F) | + | + | | cRTVH39 | Y08603 [22] #c | |
| | | 9S6 | (F) | + | + | | cRTVH40 | Y08604 [22] #c | |
| | **10** | 10S1 | (F) | + | + | | cRTVH4 | X81508 [4] #c | |
| | | 10S2 | (F) | + | + | | cRTVH4.1 | X81489 [4] #c | |
| | **11** | 11S1 | (F) | + | + | | cRTVH13 | X81511 [4] #c | |
| **Spotted wolffish (*Anarhichas minor*)** | **1** | 1S1 | (F) | + | + | | | AF138958 [9] #c | |

#c: Rearranged cDNA.

**Table 1** (continued)

**IMGT notes:**

(1) Teleostei genes are designated by a number for the subgroup, following by the letter S and a number. Rainbow trout subgroup is according to [10].
(2) Partial V-REGION:CDR3-IMGT is partial.
(3) The designation of the Arctic charr *(Salvelinus alpinus)* IGHV subgroups is according to that of the Rainbow trout *(Oncorhynchus mykiss)* IGHV subgroups [14]. Representatives of the IGHV7, IGHV9, and IGHV10 subgroups have not yet been found in the Arctic charr.
(4) Partial V-REGION: partial FR1-IMGT in 5' (AA 1 to 6 are absent).
(5) Partial V-REGION: partial FR1-IMGT in 5' (AA 1 to 17 are absent).
(6) Partial V-REGION: partial FR1-IMGT in 5' (AA 1 to 14 are absent).
(7) In frame STOP-CODON in the CDR3-IMGT.
(8) Frameshift in CDR2-IMGT.
(9) In frame STOP-CODON in the FR2-IMGT.
(10) In this column are shown the names of the lambda phages from which are derived the Reference sequences.
(11) Frameshift in FR3-IMGT.
(12) Frameshift in CDR1-IMGT and FR3-IMGT.
(13) Frameshift in FR2-IMGT.
(14) Non canonical V-HEPTAMER: CACAATA instead of CACAGTG.
(15) Partial V-REGION: AA 1 to 89 are absent (no FR1-IMGT, no CDR1-IMGT, no FR2-IMGT, no CDR2-IMGT, partial FR3-IMGT).
(16) J0317 originally assigned to *Carassius auratus* has been shown to be a human sequence (see [17] and [18] ).
(17) Non canonical V-HEPTAMER: CACTGTT instead of CACAGTG.
(18) In frame STOP-CODONs in FR1-IMGT.
(19) In frame STOP-CODONs in FR1-IMGT and in CDR1-IMGT.
(20) Rainbow trout (*Oncorhynchus mykiss*) subgroups are according to [14].

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## Table 2. Teleostei germline IGHJ genes

**Fct**: FUNCTIONALITY
**F**: Functional
**P**: Pseudogene
**ORF**: Open Reading Frame
**vg**: Vestigial
**R**: Rearranged
**T**: Transcribed
**Pr**: Translated into protein

"+" or "-" indicates if the gene sequences have been found (+) or not been found (-) rearranged (R), transcribed (T), and/or translated into protein (Pr).

| Taxon | IGHJ name | Fct | R | T | Pr | Reference sequences | Accession numbers | Sequences from the literature |
|---|---|---|---|---|---|---|---|---|
| **Atlantic salmon *(Salmo salar)*** | IGHJ1-1 | F | | | | JHA-1 | Y12391 [3] | |
| | IGHJ1-2 | F | | | | JHA-2 | Y12391 [3] | |
| | IGHJ1-3 | F | +[1] | +[1] | | JHA-3 | Y12391 [3] | |
| | IGHJ1-4 | F | | | | JHA-4 | Y12391 [3] | |
| | IGHJ1-5 | ORF(1) | | | | JHA-5 | Y12391 [3] | |
| | IGHJ2-1 | F | | | | JHB-1 | Y12392 [3] | |
| | IGHJ2-2 | F | +[1] | +[1] | | JHB-2 | Y12392 [3] | |
| | IGHJ2-3 | F | | | | JHB-3 | Y12392 [3] | |
| | IGHJ2-4 | F | | | | JHB-4 | Y12392 [3] | |
| | IGHJ2-5 | ORF(1) | | | | JHB-5 | Y12392 [3] | |
| **Channel catfish *(Ictalurus punctatus)*** | IGHJ1 | F | + | + | | JH1 | L22340 [4] | |
| | IGHJ2 | F | + | + | | JH2 | L22340 [4] | |
| | IGHJ3 | F | + | + | | JH3 | L22340 [4] | |
| | IGHJ4 | F | + | + | | JH4 | L22340 [4] | |
| | IGHJ5 | F | | | | JH5 | L22340 [4] | |
| | IGHJ6 | F | | | | JH6 | L22340 [4] | |
| | IGHJ7 | F | + | + | | JH7 | L22340 [4] | |
| | IGHJ8 | F | + | + | | JH8 | L22340 [4] | |
| | IGHJ9 | F | + | + | | JH9 | M74041 [5] | [X79482][2], [X65182][6] |
| **Ladyfish (*Elops saurus*)** | IGHJ1 | F | | | | | M26578 [1] | |

**IMGT note:** (1) Non canonical J-HEPTAMER, CACAGCT instead of CACTGTG, however rearrangement is not excluded (see [1]).

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[1] Amemiya, C. et al., Proc. Natl. Acad. Sci. USA, 87, 811-815 (1990).
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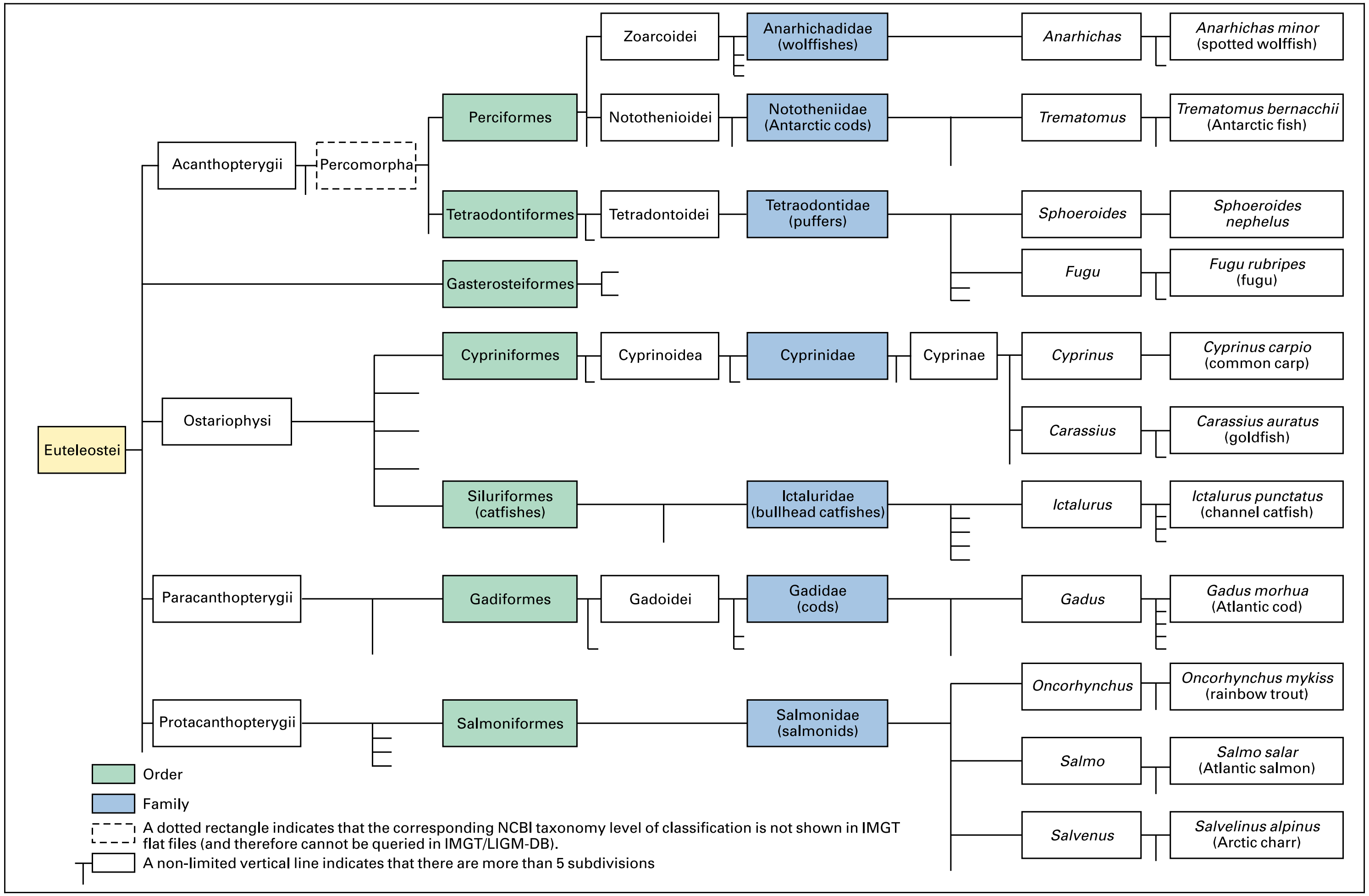

**Fig. 1.** IMGT taxonomy tree of the Euteleostei present in IMGT/LIGM-DB. Note that the Ladyfish *(Elops saurus)* which does not belong to the Euteleostei but to the Elopomorpha [Order: Elopiformes; Family: Elopidae (tenpounders)] is not shown in that figure. T cell receptor sequences, but no immunoglobulin sequences, have been so far described for *Sphoeroides nephelus*.

## Table 3. Teleostei IGHC genes and alleles

**Fct:** FUNCTIONALITY
**F**: Functional
**P**: Pseudogene
**ORF**: Open Reading Frame

| Taxon | IGHC gene name | IGHC allele name | Fct | Exons | Reference sequences | Accession numbers | Sequences from the literature |
|---|---|---|---|---|---|---|---|
| **Antarctic fish** ***(Trematomus bernacchii)*** | IGHM | IGHM*01 | F | CH1 | | AF094531 [6] c (s) | |
| | | | | CH2 | | AF094531 [6] c (s) | |
| | | | | CH3(10) | | AF094531 [6] c (s) | |
| | | | | CH4(10) | | AF094531 [6] c (s) | |
| | | | | M1(10) | | | |
| | | | | M2 | | | |
| **Arctic charr** ***(Salvelinus alpinus)*** | IGHM | IGHM*01 | F | CH1 | gACIgM | X83373[3] (2) | |
| | | | | CH2 | gACIgM | X83373 [3] | |
| | | | | CH3(1) | gACIgM | X83373 [3] | |
| | | | | CH4(1) | gACIgM | X83373 [3] (3) | |
| | | | | M1(1) | | | |
| | | | | M2 | | | |
| **Atlantic cod** ***(Gadus morhua)*** | IGHM | IGHM*01 | F | CH1 | cSg 5.1 | X58870 [5] c (s) | |
| | | | | CH2 | cSg 5.1 | X58870 [5] c (s) | |
| | | | | CH3(1) | cSg 5.1 | X58870 [5] c (s) | |
| | | | | CH4(1) | cSg 5.1 | X58870 [5] c (s) | |
| | | | | M1(1) | | | |
| | | | | M2 | | | |
| | | IGHM*02 | F | CH1 | | | |
| | | | | CH2 | | | |
| | | | | CH3(1)(4) | cSg F.1 | X58871 [5] c (m) | |
| | | | | M1(1) | cSg F.1 | X58871 [5] c (m) | |
| | | | | M2 | cSg F.1 | X58871 [5] c (m) | |
| **Atlantic salmon** ***(Salmo salar)*** | IGHM1 | IGHM1*01 | F | CH1 | lambda 6.3 (5) | Y12391 [12] | |
| | | | | CH2 | lambda 6.3 (5) | Y12391 [12] | |
| | | | | CH3(1) | lambda 6.3 (5) | Y12391 [12] | |
| | | | | CH4(1) | lambda 6.3 (5) | Y12391 [12] | |
| | | | | M1(1) | lambda 6.3 (5) | Y12391 [12] | |
| | | | | M2 | lambda 6.3 (5) | Y12391 [12] | |
| | | IGHM1*02 | F | CH1 | 7.3 (5) | Y12456 [12] c (s) | |
| | | | | CH2 | 7.3 (5) | Y12456 [12] c (s) | |
| | | | | CH3(1) | 7.3 (5) | Y12456 [12] c (s) | |
| | | | | CH4(1) | 7.3 (5) | Y12456 [12] c (s) | |
| | | | | M1(1) | 7.1 (5) | S48658 [11] c (m) | |
| | | | | M2 | 7.1 (5) | S48658 [11] c (m) | |

Table 3 (continued)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Atlantic salmon** ***(Salmo salar)*** | IGHM2 | IGHM2*01 | F | CH1 | lambda 5.1 (5) | Y12392 [12] | |
| | | | | CH2 | lambda 5.1 (5) | Y12392 [12] | |
| | | | | CH3(1) | lambda 5.1 (5) | Y12392 [12] | |
| | | | | CH4(1) | lambda 5.1 (5) | Y12392 [12] | |
| | | | | M1(1) | lambda 5.1 (5) | Y12392 [12] | |
| | | | | M2 | lambda 5.1 (5) | Y12392 [12] | |
| | | IGHM2*02 | F | CH1 | g 5.1 (5) | S48652 [11] c (s) | |
| | | | | CH2 | g 5.1 (5) | S48652 [11] c (s) | |
| | | | | CH3(1) | g 5.1 (5) | S48652 [11] c (s) | |
| | | | | CH4(1) | g 5.1 (5) | S48652 [11] c (s) | |
| | | | | M1(1) | | | |
| | | | | M2 | | | |
| | | IGHM2*03 | F | CH1 | 7.2 (5) | Y12457 [12] c (m) | |
| | | | | CH2 | 7.2 (5) | Y12457 [12] c (m) | |
| | | | | CH3(1) | 7.2 (5) | Y12457 [12] c (m) | |
| | | | | M1(1) | 7.2 (5) | Y12457 [12] c (m) | |
| | | | | M2 | 7.2 (5) | Y12457 [12] c (m) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Channel catfish** ***(ictaluruss punctatus)*** | IGHM | IGHM*01 | F | CH1 | 12c (5) | X52617 [17]/X79482[14] | C7[M74041][16](2), NG70[M27230][9] c (s) |
| | | | | CH2 | 12c (5) | X52617 [17]/X79482 [14] | NG70[M27230][9] c (s), HG103[M23733][8](8) c (s) |
| | | | | CH3(1) | 12c (5) | X52617 [17]/X79482 [14] | NG70[M27230][9] c (s), HG103[M23733][8] c (s) |
| | | | | CH4(1) | 12c (5) | X52617 [17]/X79482 [14] | NG70[M27230][9] c (s), HG103[M23733][8] c (s) |
| | | | | M1(1) | 12c (5) | X52617 [17]/X79482 [14] | |
| | | | | M2 | 12c (5) | X52617 [17]/X79482 [14] | |
| | IGHD | IGHD*01 | F | CH1 | 12c (5) | X79482 [14] | |
| | | | | CH2 | 12c (5) | X79482 [14](9) | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Common carp** ***(Cyprinus carpio)*** | IGHM1 | IGHM1*01 | F | CH1(6) | Cp1, CpM | AB004105 [15]c (s), AB004106 [15] c (m) | |
| | | | | CH2 | Cp1, CpM | AB004105 [15] c (s), AB004106 [15] c (m) | |
| | | | | CH3(1) | Cp1, CpM | AB004105 [15] c (s), AB004106 [15] c (m) | |
| | | | | CH4(1) | Cp1 | AB004105 [15] c (s) | |
| | | | | M1(1) | CpM | AB004106 [15] c (m) | |
| | | | | M2 | CpM | AB004106 [15] c (m) | |
| | | IGHM1*02 | F | CH1(6) | Cp3 | AB004107 [15] c (s) | |
| | | | | CH2 | Cp3 | AB004107 [15] c (s) | |
| | | | | CH3(1) | Cp3 | AB004107 [15] c (s) | |
| | | | | CH4(1) | Cp3 | AB004107 [15] (7) c (s) | |
| | | | | M1(1) | | | |
| | | | | M2 | | | |
| | IGHM2 | IGHM2*01 | F | CH1(6) | Cp4 | AB004108 [15] c (s) | |
| | | | | CH2 | Cp4 | AB004108 [15] c (s) | |
| | | | | CH3(1) | Cp4 | AB004108 [15] c (s) | |
| | | | | CH4(1) | Cp4 | AB004108 [15] (7) c (s) | |
| | | | | M1(1) | | | |
| | | | | M2 | | | |

| Taxon | IGHC gene name | IGHC allele name | Fct | Exons | Reference sequences | Accession numbers | Sequences from the literature |
|---|---|---|---|---|---|---|---|
| **Ladyfish** ***(Elops saurus)*** | IGHM | IGHM*01 | F | CH1 | | M26182 [1] c (s) | |
| | | | | CH2 | | M26182 [1] c (s) | |
| | | | | CH3(10) | | M26182 [1] c (s) | |
| | | | | CH4(10) | | M26182 [1] c (s) | |
| | | | | M1(10) | | | |
| | | | | M2 | | | |
| **Rainbow trout** ***(Oncorhynchus mykiss)*** | IGHM | IGHM*01 | F | CH1 | gRTIgM | X83372 [3] (2) | |
| | | | | CH2 | gRTIgM | X83372 [3] | |
| | | | | CH3(1) | gRTIgM | X83372 [3] | |
| | | | | CH4(1) | gRTIgM | X83372 [3] (7) | |
| | | | | M1(1) | | (11) | |
| | | | | M2 | | (11) | |
| | | IGHM*02 | F | CH1 | lambda RT15 | X65262 [13] (12) c (s), X65261 [13] (2) c (s) | lambda RTHC1[X67713][2](12) |
| | | | | CH2 | lambda RT15 | X65261 [13] c (s) | lambda RTtm[X65263][13](8) c (m) |
| | | | | CH3(1) | lambda RT15 | X65261 [13] c (s) | lambda RTtm[X65263][13] c (m) |
| | | | | CH4(1) | lambda RT15 | X65261 [13] c (s) | |
| | | | | M1(1) | lambda RTtm | X65263 [13] c (m) | |
| | | | | M2 | lambda RTtm | X65263 [13] c (m) | |
| | | IGHM*03 | F | CH1 | cRTVH50 | S63348 [2] c (s) | cRTVH50/CH[Y08598][4] c (s) |
| | | | | CH2 | cRTVH50 | S63348 [2] c (s) | cRTVH50/CH[Y08598][4] c (s) |
| | | | | CH3(1) | cRTVH50 | S63348 [2] c (s) | cRTVH50/CH[Y08598][4] c (s) |
| | | | | CH4(1) | cRTVH50 | S63348 [2] c (s) | cRTVH50/CH[Y08598][4] c (s) |
| | | | | M1(1) | | | |
| | | | | M2 | | | |
| | | IGHM*04 | F | CH1 | RBTIGTM2 | U04615 [10] c (m) | |
| | | | | CH2 | RBTIGTM2 | U04615 [10] c (m) | |
| | | | | CH3(1) | RBTIGTM2 | U04615 [10] c (m) | |
| | | | | M1(1) | RBTIGTM2 | U04615 [10] c (m) | |
| | | | | M2 | RBTIGTM2 | U04615 [10] c (m) | |
| | | IGHM*05 | F | CH1 | RBTIGTM1 | U04616 [10] c (m) | |
| | | | | CH2 | RBTIGTM1 | U04616 [10] c (m) | |
| | | | | CH3(1) | RBTIGTM1 | U04616 [10] c (m) | |
| | | | | M1(1) | RBTIGTM1 | U04616 [10] c (m) | |
| | | | | M2 | RBTIGTM1 | U04616 [10] c (m) | |
| **Spotted wolffish** ***(Anarhichas minor)*** | IGHM | IGHM*01 | F | CH1 | | AF138958 [7] c (s) | |
| | | | | CH2 | | AF138958 [7] c (s) | |
| | | | | CH3(10) | | AF138958 [7] c (s) | |
| | | | | CH4(10) | | AF138958 [7] c (s) | |
| | | | | M1(10) | | | |
| | | | | M2 | | | |

c: cDNA sequence.
(s) Transcript of a secreted chain.
(m) Transcript of a membrane chain.

**Table 3** (continued)

**IMGT notes:**

(1) CH3 is spliced to CH4 in secretory mu cDNA, whereas it is spliced to the M1 exon in membrane mu cDNA.
(2) Partial C-GENE: partial CH1 in 5'.
(3) Partial C-GENE: partial CH4 in 3'. M1 and M2 exons are missing.
(4) Partial C-GENE: partial CH3 in 5'.
(5) In this column are shown the names of the phages from which are derived the Reference sequences.
(6) The last ten amino acids of CH1, rich in prolin, suggest the existence of a region with hinge-like characteristics.
(7) Partial C-REGION: partial CH4 in 3'.
(8) Partial C-GENE: partial CH2 in 5'.
(9) Partial C-GENE: only CH1 and CH2 are present.
(10) By homology with other Teleostei, the CH3 is spliced to CH4 in secretory mu cDNA, whereas it is probably spliced to the M1 exon in membrane mu cDNA.
(11) Partial C-GENE: partial in 3', M1 and M2 exons are missing.
(12) Partial C-GENE: partial CH1 in 3'.

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# Table 4. FR-IMGT and CDR-IMGT length of the Teleostei IGHV genes

Only FUNCTIONAL and ORF V-GENEs are shown.
The proteolytic cleavage site between the leader peptide and the V-REGION is putative and the assignment of amino acid 1 to one or the other region is uncertain.

| Taxon | IGHV subgroup | FR1-IMGT 1 to 26 | CDR1-IMGT 27 to 38 | FR2-IMGT 39 to 55 | CDR2-IMGT 56 to 65 | FR3-IMGT 66 to 104 | CDR3-IMGT 105 to 115 |
|---|---|---|---|---|---|---|---|
| | | (25) | (8) | (17) | (7) | (38) | (2) [1] |
| **Antarctic fish (*Trematomus bernacchii*)** | 1 | -1 (aa 10) | 8 | | | -1 (aa 73) | 2 [1] |
| **Arctic charr (*Salvelinus alpinus*)** | | (24 to 27) | (7,8,10) | (17) | (6 to 8) | (36 to 38) | (2) [1] |
| | 1 | -1 (aa 10) | 7 | | 7 | -1 (aa73) | 2 [1] |
| | 2 | -1 (aa 10)<br>+2 (aa 6A,6B) | 8 | | 6.8 | -1 (aa73) | 2 [1] |
| | 3 | -1 (aa 10) | 10 | | 7 | -1 (aa73) | 2 [1] |
| | 4 | -1 (aa 10) | 8 | | 6 | -1 (aa73) | 2 [1] |
| | 5 | -1 (aa 10) | 8 | | 6.8 | -1 (aa73) | 2 [1] |
| | 6 | -2 (aa 1,10) | 7 | | 6.7 | -1 (aa73) | 2 [1] |
| | 8 | | 8 | | 7 | -3 (aa73,81,82) | 2 [1] |
| | 11 | -1 (aa 10) | 8 | | 7 | -2 (aa73,82) | 2 [1] |
| **Atlantic cod (*Gadus morhua*)** | | (25) | (6,7,12) | (17) | (6,7) | (38) | (2) [1] |
| | 1 | -1 (aa 10) | 12 | | 7 | -1 (aa73) | 2 [1] |
| | 2 | -1 (aa 10) | 6 | | 7 | -1 (aa73) | 2 [1] |
| | 3 | -1 (aa 10) | 6.7 | | 6 | -1 (aa73) | 2 [1] |
| **Atlantic salmon (*Salmo salar*)** | | (25) | (8) | (17) | (7) | (38) | (3) |
| | 1 | -1 (aa 10) | 8 | | 7 | -1 (aa 73) | 3 |
| **Channel catfish (*Ictalurus punctatus*)** | | (25) | (8,10,12) | (17) | (6 to 8) | (38) | (3) |
| | 1 | -1 (aa 10) | 8 | | 7 | -1 (aa 73) | 3 |
| | 2 | -1 (aa 10) | 7 | | 7 | -1 (aa 73) | 3 [1] |
| | 3 | -1 (aa 10) | 8 | | 6,8 | -1 (aa 73) | 3 |
| | 4 | -1 (aa 10) | 10 | | 7 | -1 (aa 73) | 3 |
| | 5 | -1 (aa 10) | 12 | | 7 | -1 (aa 73) | 3 [1] |
| | 6 | -1 (aa 10) | 10 | | 7 | -1 (aa 73) | 3 |
| | 7 | -1 (aa 10) | 8 | | 8 | -1 (aa 73) | 3 [1] |
| **Fugu (*Fugu rubripes*)** | | (25) | (7,8) | (17) | (7,8) | (38) | (2,3) |
| | 1 | -1 (aa 10) | 8 | | 7.8 | -1 (aa 73) | 3 |
| | 2 | -1 (aa 10) | 7 | | 7.8 | -1 (aa 73) | 2 |

**Table 4** (continued)

| **Goldfish**<br>***(Carassius auratus)*** |  | (25) | (8) | (17) | (6,7) | (38) | (2,3) |
|---|---|---|---|---|---|---|---|
|  | 1 | -1 (aa 10) |  |  | 7 | -1 (aa 73) | 2 |
|  | 2 | -1 (aa 10) |  |  | 6 | -1 (aa 73) | 3 |

| **Ladyfish**<br>**(*Elops saurus*)** |  | (25) | (8,1) | (17) | (7,8) | (38) | (2) [1] |
|---|---|---|---|---|---|---|---|
|  | 1 | -1 (aa 10) | 8 |  | 8 | -1 (aa 73) | 2 [1] |
|  | 2 | -1 (aa 10) | 10 |  | 7 | -1 (aa 73) | 2 [1] |

| **Rainbow trout**<br>***(Oncorhynchus mykiss)*** |  | (24 to 27) | (7,8,10,12) | (17) | (6 to 9) | (36 to 38) | (2) |
|---|---|---|---|---|---|---|---|
|  | 1 | -1 (aa 10) | 7.8 |  | 7,8,9 | -1 (aa 73) | 2 |
|  | 2 | -1 (aa 10)<br>+2 (aa 6A,6B) | 8 |  | 6 | -1 (aa 73) | 2 [1] |
|  | 3 | -1 (aa 10) | 10 |  | 7 | -1 (aa 73) | 2 [1] |
|  | 4 | -2 (aa 1,10) | 8 |  | 9 | -1 (aa 73) | 2 [1] |
|  | 5 | -1 (aa 10) | 8 |  | 8 | -1 (aa 73) | 2 [1] |
|  | 6 | -2 (aa 1,10) | 7 |  | 6 | -1 (aa 73) | 2 [1] |
|  | 7 | -1 (aa 10) | 12 |  | 7 | -1 (aa 73) | 2 [1] |
|  | 8 | -2 (aa 10,11)<br>-1 (aa 10) | 8 |  | 7 | -3 (aa 73,82,83) | 2 [1] |
|  | 9 | -1 (aa 10) | 8 |  | 7 | -1 (aa 73) | 2 [1] |
|  | 10 | -1 (aa 10) | 8 |  | 6 | -1 (aa 73) | 2 [1] |
|  | 11 | -1 (aa 10) | 8 |  | 7 | -2 (aa 73,82) | 2 [1] |

| **Spotted wolffish**<br>***(Anarhichas minor)*** |  | (25) | (7) | (17) | (6) | (38) | (2) [1] |
|---|---|---|---|---|---|---|---|
|  | 1 | -1 (aa 10) | 7 |  | 6 | -1 (aa 73) | 2 [1] |

**IMGT note:** [1] Probable CDR3-IMGT length but needs to be confirmed with germline sequences.

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