A Rare Blood Group Antigen An^a (Ahonen)

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On 5 May 1968, Mr A.L., aged 66, a patient in The University Central Hospital, Helsinki, suffering from an aortic aneurysm, was found at post-operative cross-matching to be incompatible with one of several potential donors, Miss K.A. Mr A.L. was not known to have been transfused until 24 April 1968 when he received the first of 7 compatible units of blood but, as will be seen below, these were probably not responsible for the presence of his antibody.

The antibody in the serum of Mr A.L. was named anti-An^a: the antigen An^a is rare, at any rate in Finland and Sweden the only countries in which it has been widely sought. If, as seems likely, the antigen does represent a new blood group system then the systemic name can be Ahonen.

Serological Details

The groups of Mr A.L. in whose serum the first example of anti-An^a was found are: An(a-), A₁, MNSs, P₁, R₁R₂, Lu(a-), K-, Le(a-b+), Fy(a+b+), Xg(a+).

The anti-An^a in the serum of Mr A.L. reacts weakly against An(a+) cells in saline at 37° C but more strongly at lower temperatures; it reacts well by the antiglobulin method using routine antiglobulin sera. With more specific antiglobulin sera this anti-An^a reacts best with anti-IgG.

The An^a:anti-An^a reaction is inhibited by treatment of the cells with papain but not with ficin; it was not inhibited by the saliva of An(a+) people whether ABH secretors or not, or by hydatid cyst fluid of sheep origin. Anti-An^a is readily absorbed by An(a+) cells.

By testing An(a+) cells against a battery of antisera to antigens known to be rare, or by testing anti-An^a against cells known to contain rare antigens, An^a was shown not to be any of the following antigens: Be^a, Bp^a, By, Gf, Jn^a, Levay, Ls^a, Sk^a, Sw^a, To^a, Tr^a, Wb, Wr^a, Sul, Wu, Bi, Di^a, Rd, Ul^a, Mo^a, Hov, and 12 other 'private' antigens which have yet

to be shown to be inherited; also excluded were the rare antigens belonging to the MNSs and Rh systems, such as M^ε, E^w, etc (which are further excluded by the genetical independence of An^a of these systems, as recorded below). An^a was also distinguished from the antigens P^k, K, Kp^a, Js^a, Yt^b, Bu^a, Bg^a, Bg^b and Sd^a. Further, anti-An^a did not react with cells of the following phenotypes lacking very common antigens and so is not directed at any unknown antigens they may possess: O_h, U-, Luke(-), pp, LW-, Rh_{null}, -D-/-D-, Lu(a-b-), K_o, Fy(a-b-), Vel-, Lan-, Ge(a-), Co(a-), Yt(a-b+), Gy(a-), Cs(a-), Chido-, and cells of rare phenotypes associated with the Kell and Lutheran systems. (Again, some of these were further ruled out because of genetic independence between An^a and the system to which they belong.)

Frequency of An^a

Of 10,000 unrelated Finnish donors and patients tested with the serum of A.L., 6 were found to be An(a+). It will be seen below that the antigen An^a is a dominant character and on this basis the following frequencies for Finland may be calculated; they can only be approximate because of the small number of An(a+) involved:

Phenotypes		Genes	Genotypes	
An(a+)	0.0006	An ^a	0.0003	An ^a An ^a 0.0000
An(a-)	0.9994	An	0.9997	An ^a An 0.0006
				AnAn 0.9994

Of 3266 Swedish donors, selected for having Swedish names, 2 were An(a+), a distribution indistinguishable from that in Finland.

According to usual practice the so far silent allele of An^a is called An: should anti-An turn up An will be promoted to An^b. Anti-An^b would react with virtually all cells tested except the person's own and perhaps some of his sibs.

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FIGS. 1-7. Families illustrating the inheritance of the antigen An^a . Black = $An(a+)$; dot = $An(a-)$; hollow = not tested; cross = dead; arrow = probandus. (The blood groups are given in the Appendix.)

FIG. 1. Pedigree of family Sim.

Inheritance of the Antigen An^a

One hundred and sixty-nine relatives of 7 $An(a+)$ Finnish probandi were tested with anti- An^a and for most of the other blood groups. Pedigrees of the 7 kinships are shown in Figs. 1-7 and a list of their blood groups is in the Appendix.

The count given in Table I shows the antigen An^a to be a dominant character.

Genetical Independence of Other Systems.

Genetic recombination in the families showed that An^a is not sited at the loci for any of the following blood group systems: ABO, MNSs, P, Rh, secretor

TABLE I

INHERITANCE OF THE ANTIGEN An^a : DATA FROM THE KINSHIPS OF SEVEN FINNISH PROBANDI

Mating	No. of Families	Offspring	
		$An(a+)$	$An(a-)$
$An(a+) \times An(a-)$	23	38*	40
$An(a-) \times An(a-)$	3	0	17

* $An(a+)$ probandi (3) are excluded from this count.

(as derived from the Lewis groups of the red cells), Duffy, Kidd, Dombrock or Xg. Nor is An^a X- or Y-linked. Recombination also excluded Gc and

FIG. 2. Pedigree of family Sal.

FIG. 3. Pedigree of family Luu.

FIG. 4. Pedigree of family Nor.

FIG. 5. Pedigree of family Jok.

FIG. 6. Pedigree of family Hei.

FIG. 7. Pedigree of family Pel.

H_p: the single small family in which An^a and *Tf* were segregating did not show that they are not at the same locus but gave practically no evidence that they are related in any way.

Before An^a can be claimed with confidence to be the herald of a 'new' blood group system it needs to be shown to be genetically independent of the loci for Lutheran, Kell, Diego, Yt and Colton. Lutheran may prove difficult and so may Kell for the alleles Lu^a , K and Kp^a are somewhat rare in Finland and U^l^a though commoner there than anywhere else tested has a frequency of only about 1.3%. Information about Diego will have to

await the testing with anti- An^a of remote populations and attempts to dissociate Yt and Colton are held up by shortage of anti-Yt^b and anti-Co^b sera.

Linkage Tests with Anti- An^a . There is no evidence that the *An* locus is within measurable distance of any of the marker loci for which information is available (Table II). The lod scores were calculated as instructed by Maynard-Smith, Penrose, and Smith (1961). To establish autosomal linkage the sum of the lod scores at the most likely recombination fraction should reach +3, and none in Table II approaches this.

TABLE
FAILURE TO DETECT LINKAGE BETWEEN THE LOCUS FOR An^a AND THOSE

Transmission through Doubly Heterozygous Males									
Loci	No. of scoring Fathers: Children		Phase known Non-recombinant: Recombinant		Recombination Fraction (θ')				
					0.05	0.1	0.2	0.3	0.4
<i>ABO</i>	5	24	13	11	-7.373	-4.374	-1.726	-0.544	-0.040
<i>MNSs</i>	11	40	7	14	-14.423	-9.215	-4.506	-2.177	-0.819
<i>P</i>	3	8		1	-2.997	-1.903	-0.911	-0.419	-0.142
<i>Rh</i>	13	47	12	13	-10.106	-5.710	-2.095	-0.694	-0.169
<i>Se†</i>	2	6			-0.465	-0.231	-0.060	-0.012	-0.001
<i>Fv</i>	7	21	5	4	-3.977	-2.172	-0.702	-0.151	+0.020
<i>Yk</i>	4	16	3	7	-8.327	-5.459	-2.756	-1.343	-0.495
<i>Do</i>									
<i>Hp</i>	4	17		2	-5.091	-3.187	-1.498	-0.693	-0.248
<i>Gc</i>	6	23	2	5	-8.511	-5.432	-2.612	-1.207	-0.415
<i>Tf</i>									

* No family scored for Lu or for K.
† As judged by the Lewis groups of the red cells.

Frequency of Anti-An^a

After the original anti-An^a of Mr A.L. had defined the antigen An^a, An(a+) cells were used to look for further examples of the antibody. Anti-An^a was found in the serum of 6 out of 5350 Finnish donors (0.11%), 2 out of 1868 Finnish patients (0.11%), and 5 out of 1693 Swedish donors (0.30%). These figures do not show a significant difference of distribution of the antibody in the two countries. Neither of the two Finnish patients had ever been transfused.

The antibody must usually be 'naturally occurring'. It is unusual, though not unknown (Mollison, 1967), for 'naturally occurring' antibodies to react by the IgG antiglobulin method.

There is no evidence that pregnancy can stimulate the antibody: in the 7 kinships, 14 An(a-) mothers had had at least one An(a+) child and 8 of them had had more than one but none of the mothers had anti-An^a in her serum. However, the opportunity has not yet arisen of testing the cord cells of the offspring of An(a+) people, so it is not known whether the antigen is developed at birth.

Nor is it likely that transfusion originates the antibody: when the frequency of the antigen An^a and of anti-An^a are similar to those observed in

Finland the chance of a positive cross-match due to anti-An^a is about 1 in 1.5 million tests.

Summary

The first example of anti-An^a disclosed itself at cross-matching. The corresponding antigen, An^a, is rare: 6 examples were found in tests on 10,000 Finnish and 2 examples in 3266 Swedish donors. The 'new' antigen is a dominant character and was shown, by independent segregation in families, not to belong to the ABO, MNSs, P, Rh, secretor, Duffy, Kidd or Dombrock systems, nor to be X- or Y-linked. The antigen has yet to be shown to be genetically independent of the Lutheran, Kell, Yt, Diego and Colton blood group systems.

Further examples of anti-An^a were soon found: it occurs in the serum of about 1 in 1000 normal people, and evidence of stimulation by transfusion or pregnancy is notably lacking.

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II

FOR OTHER GENETIC CHARACTERS OF THE BLOOD: SUMMARY OF LOD SCORES*

Transmission through Doubly Heterozygous Females									
No. of Scoring Mothers: Children		Phase known Non-recombinant: Recombinant		Recombination Fraction (θ)					Loci
				0.05	0.1	0.2	0.3	0.4	
4	16	7	6	-4.816	-2.891	-1.176	-0.396	-0.049	ABO
6	21	6	6	-6.280	-3.819	-1.634	-0.629	-0.146	MNSs
2	9			-0.698	-0.240	+0.050	+0.078	+0.030	P
6	19	4	12	-10.399	-6.941	-3.664	-1.920	-0.801	Rh
1	2	2		+0.558	+0.510	+0.408	+0.292	+0.158	Se†
4	13	4	5	-3.472	-2.129	-0.955	-0.421	-0.141	Fy
3	6			-0.025	-0.014	+0.074	+0.052	+0.016	Jk
1	3			-0.769	-0.482	-0.216	-0.086	-0.020	Do
2	8			-0.927	-0.458	-0.120	-0.023	-0.001	Hp
2	7			+0.072	+0.237	+0.258	+0.159	+0.048	Gc
1	2			+0.258	+0.215	+0.134	+0.064	+0.017	Tf

Appendix

Red Cell and Serum Groups of the Families in Figs. 1-7

	An ^a	ABO	MNSs	P ₁	Rh	Lu ^a	K	k	Kp ^a U ^l	Le ^a Le ^b	Fy ^a Fy ^b	Jk ^a Jk ^b	Xg ^a	Do ^a	Tf	Gc	Hp
Family Sim.	-	A ₁	Ms/Ns	-	rr	-	-	-	-	-	+	+	+	-	UUUUU	1-2	2-1
II.2	-	B	Ns/Ns	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
II.3	+	A ₂	NS/NS	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-1
II.4	-	A ₁ B	Ms/Ms	-	R ₂ R ₂	-	-	-	-	-	+	+	+	+	UUUUU	1-2	1-1
II.5	-	B	Ms/Ns	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-2
II.6	-	B	Ms/Ns	+	R ₁ R ₂	-	-	+	-	+	+	+	+	-	UUUUU	1-1	2-1
II.8	-	A ₂ B	Ms/Ns	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
II.9	-	A ₁	MNSs	+	R ₂ R ₂	-	-	-	-	-	+	+	+	+	UUUUU	1-2	2-1
II.10	+	B	NS/NS	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.1	-	B	MS/Ns	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.2	-	A ₁ B	Ms/Ms	+	rr	-	-	-	-	-	+	+	+	+	UUUUU	1-2	2-1
III.3	-	A ₁	MNSs	+	R ₁ R ₁	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-2
III.4	+	A ₁	Ms/Ns	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-1
III.5	+	O	Ms/Ns	+	R ₁ ^u R ₂	-	+	-	-	+	+	+	+	+	UUUUU	1-1	2-2
III.6	+	A ₁	Ms/Ns	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	1-1
III.9	-	O	Ms/NS	+	R ₀ r	-	-	+	-	+	+	+	+	+	UUUUU	1-2	2-2
III.10	-	A ₂ B	Ms/Ns	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	2-2	1-1
III.11	-	A ₁	Ms/Ns	+	R ₂ r	-	-	-	-	-	+	+	+	+	UUUUU	1-1	2-2
III.12	+	A ₁	Ms/Ns	+	R ₁ r	-	-	-	-	-	+	+	+	+	UUUUU	1-1	1-1
III.13	-	A ₂	MS/Ms	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.14	+	A ₂ B	Ms/Ns	-	R ₂ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.16	-	A ₁	Ms/Ns	+	R ₁ r	-	-	-	-	-	+	+	+	+	UUUUU	1-2	2-1
III.17	+	A ₁	Ms/NS	-	R ₁ r	-	-	-	-	-	+	+	+	+	UUUUU	2-2	2-1
III.19	+	O	Ms/Ns	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-1
III.20	+	A ₁	Ms/Ns	-	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.21	-	B	Ms/Ns	+	R ₁ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.22	-	A ₁	Ms/Ns	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.23	-	B	Ms/Ms	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.24	+	A ₁	Ms/Ns	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1
III.25	-	A ₁ B	Ms/Ns	-	R ₁ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	2-2	2-2
III.27	-	A ₂	MNSs	+	R ₂ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.28	-	A ₂ B	Ms/Ns	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-2
III.29	-	A ₂	Ms/Ns	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1
III.30	-	B	Ms/Ns	+	R ₁ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	2-2	2-2
III.31	-	B	Ms/Ns	+	R ₁ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.32	-	A ₁ B	Ms/Ns	-	R ₁ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.33	-	O	MNSs	-	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-1	1-1
III.34	-	O	Ms/Ms	+	R ₁ R ₁	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-2
III.35	-	A ₂	MNSs	+	R ₂ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1
III.36	-	A ₂	Ms/Ns	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.37	-	A ₁	MS/Ms	+	R ₁ r	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1
III.38	-	A ₂	MNSs	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-1
III.39	-	A ₂	Ms/Ns	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-2
III.40	-	A ₂	Ms/Ms	+	R ₂ R ₂	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.41	-	A ₂	Ms/Ms	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1
III.42	-	A ₂	Ms/Ms	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-2	2-2
III.45	-	A ₂	Ns/Ns	+	rr	-	-	-	-	+	+	+	+	+	UUUUU	1-1	2-1

Appendix—continued

	An ^a	ABO	MNSs	P ₁	Rh	Lu ^a	K	k	Kp ^a U ^{1a}	Le ^a Le ^b	Fy ^a Fy ^b	Jk ^a Jk ^b	Xg ^a	Do ^a	Tf	Gc	Hp
<i>Family Sim.</i>																	
IV.1	+	B	MS/Ns	—	R ₁ r	—	—	—	—	—	+	—	+	+	C	1-2	2-2
IV.2	—	A ₂ B	MS/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.3	—	B	MS/Ns	—	rr	—	—	—	—	—	+	+	+	+	C	1-2	2-2
IV.4	+	B	NS/Ns	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	2-2	2-2
IV.5	—	B	NS/Ns	—	R ₁ R ₁	—	—	—	—	—	+	+	+	+	C	1-2	2-2
IV.6	—	B	Ns/Ns	—	R ₁ R ₁	—	—	—	—	—	+	+	+	+	C	2-2	2-2
IV.7	—	B	MS/Ms	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.8	—	A ₁ B	MS/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.9	—	B	Ms/Ns	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.10	+	A ₂	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	—	+	+	—	—	1-2	2-1
IV.11	—	O	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.12	—	A ₁	Ms/Ms	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.13	—	A ₂	Ms/Ms	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.14	+	A ₁	Ms/Ms	+	R ₁ R ₂	—	—	—	+	—	+	+	+	+	C	1-1	2-1
IV.15	—	A ₂	Ms/Ns	+	R ₁ r	—	+	+	—	—	+	+	+	+	C	1-1	2-2
IV.16	+	A ₁	Ms/Ms	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.17	—	A ₁	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.18	—	A ₂	Ms/Ms	+	R ₁ r	—	+	+	—	—	+	+	+	+	C	1-2	2-1
IV.19	—	A ₁	Ms/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.20	—	A ₁	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.21	+	A ₂	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.22	+	A ₁	Ms/Ms	+	R ₁ r	—	—	—	+	—	+	+	+	+	C	1-1	2-1
IV.23	+	A ₂	Ms/Ns	—	rr	—	—	—	—	+	+	+	+	+	C	2-2	2-1
IV.24	—	A ₂	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	2-2	2-1
IV.25	+	A ₂	NS/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	2-2	2-1
IV.26	—	A ₁ B	Ms/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.27	—	A ₂	Ms/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.28	—	B	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.29	—	B	Ms/Ns	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.30	—	A ₂	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.31	—	B	Ms/Ms	—	R ₂ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.32	—	A ₂	Ms/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.33	—	A ₁	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
IV.34	+	A ₂	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.35	+	A ₂	MS/Ms	—	rr	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.36	+	A ₁	MS/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.37	—	A ₁	Ms/Ns	—	rr	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.38	—	B	Ms/Ms	—	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
IV.39	—	A ₂	Ms/Ns	—	R ₂ r	—	+	+	—	—	+	+	+	+	C	1-1	2-1
IV.40	+	B	Ms/Ns	—	rr	—	+	+	—	—	+	+	+	+	C	1-1	2-1
IV.41	—	B	Ms/Ns	—	R ₂ r	—	+	+	—	—	+	+	+	+	C	1-1	2-1
IV.42	—	A ₂ B	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-2
IV.43	—	A ₁	Ms/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	1-2	1-1
IV.44	+	A ₂	Ms/Ns	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.45	+	A ₁	Ms/Ns	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.46	—	A ₂	Ms/Ns	+	R ₂ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.47	—	A ₁	Ns/Ns	—	R ₂ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.48	+	A ₁	Ms/Ms	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.49	—	A ₁	Ms/Ms	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
IV.50	—	A ₁	Ms/Ns	—	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	1-1
V.1	—	A ₂ B	MS/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-2
V.2	+	A ₂ B	MS/Ns	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
V.3	—	O	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
V.4	+	O	Ms/Ns	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-1
V.5	—	O	Ms/Ns	+	R ₂ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
V.6	+	A ₂	Ms/Ms	+	R ₂ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-1
V.7	+	O	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-2
V.8	+	O	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-2
V.9	+	A ₂	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-2
V.10	+	A ₁	Ms/Ms	+	R ₁ R ₂	—	—	—	—	—	+	+	+	+	C	1-1	2-2
<i>Family Sal.</i>																	
I.2	+	O	Ms/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
I.3	—	A ₂	Ms/Ns	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
I.4	—	O	Ms/Ns	—	R ₀ r	—	—	—	—	—	+	+	+	+	C	1-1	2-2
I.5	+	A ₁	Ms/Ns	—	R ₁ R ₁	—	—	—	—	—	+	+	+	+	C	1-1	1-1
II.1	+	A ₁	MS/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-2	2-1
II.2	—	O	MS/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
II.3	—	A ₂	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
II.4	—	A ₂	Ms/Ns	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	1-1
II.5	+	O	Ms/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	1-1
II.6	+	O	Ms/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
II.7	+	O	Ms/Ms	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
II.8	+	O	Ms/Ms	—	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1
III.1	—	A ₁	MS/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-2	2-1
III.2	+	A ₁	MS/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
III.3	+	A ₁	MS/Ms	+	rr	—	—	—	—	—	+	+	+	+	C	1-1	2-1
III.4	+	A ₁	MS/Ms	+	R ₁ r	—	—	—	—	—	+	+	+	+	C	1-1	2-1

Appendix—continued

	An ^a	ABO	MNSs	P ₁	Rh	Lu ^a	K	k	Kp ^a U1 ^a	Le ^a Le ^b	Fy ^a Fy ^b	Jk ^a Jk ^b	Xg ^a	Do ^a	Tf	Gc	Hp
Family Luu.																	
II.1	+	A ₁	MS/MS	—	R ₁ R ₂	—	—	—	—	—	—	+	—	—	C	1-2	2-2
II.2	—	B	MS/NS	—	R ₁ R ₂	—	—	—	—	—	+	—	—	—	C	1-1	2-2
II.3	+	O	MS/NS	+	R ₁ R ₂	—	—	—	—	—	+	+	—	—	C	1-1	1-1
II.4	—	O	MS/MS	+	R ₂ R ₂	—	—	—	—	—	+	—	—	—	CD Chi	1-1	2-1
II.5	—	O	MN	+	R ₁ R ₁	—	—	—	—	—	—	—	—	—	C	1-1	1-1
III.1	—	A ₁	MS/NS	—	R ₂ r	—	—	—	—	—	+	—	—	—	C	1-1	2-1
III.2	—	O	MS/NS	+	R ₂ R ₂	—	—	—	—	—	+	+	—	—	CD Chi	1-1	1-1
III.3	—	O	MS/NS	+	R ₁ R ₂	—	—	—	—	—	+	+	—	—	CD Chi	1-1	1-1
III.4	—	O	MS/MS	+	R ₁ R ₂	—	—	—	—	—	+	+	—	—	CD Chi	1-1	1-1
III.5	—	O	MM	+	R ₁ R ₂	—	—	—	—	—	+	—	—	—	—	—	2-1
Family Nor.																	
I.1	+	O	MS/MS	+	R ₁ R ₂	—	—	—	—	—	+	+	—	—	C	1-1	2-1
I.2	—	A ₁	NS/NS	+	R ₁ r	—	—	—	—	—	+	—	—	—	C	1-1	2-1
II.1	+	O	MS/NS	+	R ₂ r	—	—	—	—	—	+	+	—	—	B ₂ -C	1-1	2-2
II.2	+	O	MS/NS	+	R ₁ r	—	—	—	—	—	+	+	—	—	C	1-1	2-1
Family Jok.																	
I.1	+	A ₁	MS/MS	+	R ₁ R ₁	—	—	—	—	+	—	+	+	—	CD Chi	1-2	2-1
II.1	—	A ₂	MS/NS	+	R ₁ r	—	—	—	—	+	+	+	—	—	C	1-1	2-2
II.2	—	A ₁	MS/MS	+	R ₁ r	—	—	—	—	+	—	+	—	—	C	1-1	2-2
II.3	+	A ₁	MS/MS	+	R ₁ r	—	—	—	—	+	—	+	—	—	C	1-1	2-2
III.1	—	A ₁	MS/MS	+	rr	—	—	—	—	+	—	+	—	—	C	1-1	2-2
III.2	—	A ₁	MS/NS	+	R ₁ R ₁	—	—	—	—	—	+	+	—	—	C	1-1	2-2
III.3	—	A ₁	MS/NS	+	R ₁ r	—	—	—	—	—	+	+	—	—	C	1-1	2-2
III.4	+	A ₁	MS/MS	+	R ₁ R ₁	—	—	—	—	+	—	+	—	—	C	1-1	2-2
Family Pel.																	
I.1	+	O	MS/NS	+	R ₂ r	—	—	—	—	—	+	+	+	—	C	1-1	2-1
I.2	—	B	MS/MS	+	R ₁ R ₂	—	—	—	—	—	+	+	+	—	C	1-1	2-2
I.3	—	O	MS/MS	+	R ₁ R ₂	—	—	—	—	—	+	+	+	—	C	1-1	2-1
I.4	+	O	MS/MS	+	R ₂ r	—	—	—	—	—	+	+	+	—	C	1-2	2-1
I.5	—	O	MS/NS	+	R ₁ R ₂	—	—	—	—	—	—	+	+	—	C	1-1	2-1
I.6	—	O	MS/MS	+	R ₂ R ₂	—	—	—	—	—	—	+	+	—	C	1-1	1-1
I.7	+	O	MS/MS	+	R ₁ r	—	—	—	—	—	—	+	+	—	B ₂ -C	1-1	2-1
I.8	—	B	MS/MS	—	rr	—	—	—	—	—	+	+	+	—	C	1-2	2-2
I.9	—	O	MS/MS	+	R ₂ R ₂	—	—	—	—	—	+	+	+	—	C	1-2	2-1
I.10	+	O	MS/MS	+	R ₁ r	—	—	—	—	—	—	+	+	—	C	1-2	2-1
I.11	+	O	MS/NS	+	R ₁ R ₂	—	—	—	—	—	+	—	+	—	C	1-1	1-1
I.12	—	A ₂ B	MS/MS	+	R ₁ R ₁	—	—	—	—	—	+	—	+	—	C	1-1	1-1
I.13	+	O	MNSs	+	R ₂ R ₂	—	—	—	—	—	+	—	+	—	C	1-2	2-1
II.1	+	O	MS/MS	+	R ₁ R ₂	—	—	—	—	—	+	—	+	—	C	1-1	2-2
II.2	—	A ₁	MS/MS	+	R ₂ r	—	—	—	—	—	—	—	—	—	C	1-1	1-1
II.3	—	B	MS/MS	+	R ₂ r	—	—	—	—	—	+	—	+	—	C	1-1	2-2
II.5	—	B	MS/MS	+	R ₂ r	—	—	—	—	—	+	—	+	—	C	1-1	2-2
II.6	—	O	MS/MS	—	R ₁ r	—	—	—	—	—	—	—	+	—	C	1-1	2-2
II.7	—	O	MS/NS	+	R ₁ r	—	—	—	—	—	+	—	+	—	C	1-2	1-1
II.8	+	O	MMS	+	rr	—	—	—	—	—	—	—	—	—	C	—	—
II.9	—	O	MS/MS	+	R ₁ r	—	—	—	—	—	+	+	+	—	C	1-2	2-1
II.10	—	B	MS/MS	+	R ₁ R ₁	—	—	—	—	—	+	—	+	—	C	1-1	1-1
II.11	—	B	MS/NS	+	R ₁ R ₂	—	—	—	—	—	—	—	+	—	C	1-1	1-1
II.12	—	A ₂	MS/NS	+	R ₁ R ₂	—	—	—	—	—	—	—	+	—	C	1-1	1-1
III.1	—	O	MMS	+	R ₂ R ₂	—	—	—	—	—	—	—	—	—	C	—	—
III.2	+	A ₁	MS/MS	+	R ₂ r	—	—	—	—	—	+	—	—	—	C	1-1	1-1
Family Hei.																	
I.1	—	B	MS/NS	—	R ₁ ^w R ₂	—	—	—	—	—	+	—	—	—	C	1-1	1-1
II.1	+	B	NS/NS	—	R ₁ ^w R ₂	—	—	—	—	—	—	—	—	—	C	1-1	2-1
II.2	—	B	MS/MS	—	R ₂ R ₂	—	—	—	—	—	+	—	+	—	C	1-1	2-1
II.3	—	B	MS/MS	—	R ₁ R ₂	—	—	—	—	—	+	—	+	—	C	1-1	1-1
II.4	+	B	MS/NS	—	R ₁ ^w R ₂	—	—	—	—	—	—	—	+	—	C	1-1	2-1
II.5	+	O	MS/MS	—	R ₁ ^w R ₂	—	—	—	—	—	—	—	—	+	C	1-1	1-1