BLOOD GROUPS

1. ABO series

Group	Genotype	Cellular Antigens	Serum Antibodies	Frequency in U.S.
O	O/O	none	anti-A, anti-B	41%
A	A/A, A/O	A	anti-B	40%
B	B/B, B/O	B	anti-A	12%
AB	A/B	A,B	none	7%

A has been subdivided into A_1 and A_2---possibly several more.

2. MNS

Group	Genotype	Antigens	Reaction with anti-M	anti-N	anti-S	anti-s
MS	MS/MS	M,S	+	-	+	-
Ms	Ms/Ms	M,s	+	-	-	+
MSs	MS/Ms	M,S,s	+	-	+	+
NS	NS/NS	N,S	-	+	+	-
Ns	Ns/Ns	N,s	-	+	-	+
NSs	NS/Ns	N,S,s	-	+	+	+
MNS	MS/NS	M,N,S	+	+	+	-
MNs	Ms/Ns	M,N,s	+	+	-	+
MNSs	MS/Ns, Ms/NS	M,N,S,s	+	+	+	+

Antibodies to M and N are ordinarily produced only by rabbits; rarely produced by humans. Anti-S and anti-s are occasionally produced by humans.

3. Rh factor

There has been much research on the Rh factor in the years since 1941. Out of this work two principal hypotheses as to the nature of the genes controlling the antigens and two systems of terminology have grown. According to Wiener the various Rh factors are inherited as multiple allelomorphs. Fisher has postulated that there are three closely linked genes which never, or very rarely, cross over. Since both theories lead to the same practical consequences (genes which cannot be separated lead to the same system of heredity as a single gene), the distinction between the two theories is not of practical importance. There is a growing tendency to use the terminology suggested by Fisher because of its greater simplicity.

Wiener's system included 6 allelomorphic genes determined on the basis of four kinds of sera. Fisher studied the data and elaborated his theory which predicted existence and possible future discovery of two additional kinds of sera and two more genes. Since that time these sera and genes have been found.

The genes and their reactions with the six types of antisera are listed below.

Fisher / Wiener		Reaction with anti-C anti-Rh'	anti-D anti-Rh^0	anti-E anti-Rh"	anti-c anti-Hr'	anti-d anti-Hr^0	anti-e anti-Hr"	Frequency in Eng.
Genes Fisher	Wiener							%
cde	r	-	-	-	+	+	+	38.9
Cde	R'	+	-	-	-	+	+	1.0
cdE	R"	-	-	+	+	+	-	1.2
CdE	R'"=Ry	+	-	+	-	+	-	.0
cDe	R^0	-	+	-	+	-	+	2.6
CDe	R^0=R^1	+	+	-	-	-	+	42.0
cDE	R^0=R^2	-	+	+	+	-	-	14.1
CDE	R$^{0'"}$=R^z	+	+	+	-	-	-	.2

These genes occur in any person two at a time, so that one might have any combination of two of the factors. This means that there are 36 possible genotypes of which 27 are serologically distinguishable. A person with any two factors reacts with any serum that either of the two would react with. Hence it is easily possible to figure out exactly what sera would agglutinate blood of any genotype. Some of the various genotypes are given in the table following.

Genotypes	Freq. %	Reaction with anti-C anti-Rh'	anti-D anti-Rh^0	anti-E anti-Rh"	anti-c anti-Hr'	anti-d anti-Hr^0	anti-e anti-Hr"
cde/cde	14.36	-	-	-	+	+	+
cdE/cde	1.23	-	-	+	+	+	+
cDe/cde	2.31	-	+	-	+	+	+
CDe/CDe	19.02	+	+	-	-	-	+
CDe/cDe	2.66	+	+	-	+	-	+
CDe/cde	33.06	+	+	-	+	+	+
cDE/cde	9.70	-	+	+	+	+	+
CDe/cDE	11.16	+	+	+	+	-	+

Most cases of erythroblastosis are due to the anti-D (anti-Rh$_0$) factor. Most of the others are due to anti-C. Anti-d is very rare. There are further subdivisions; for example, C^W, C^u, c^V.

Antibodies can be made only by persons not possessing that antigen. For example: anti-D comes only from dd persons immunized with DD or Dd cells.

4. Kell-Cellano

Genotype	Reaction with anti-K	anti-k
K/K	+	-
K/k	+	+
k/k	-	+

Anti-K is usually found in kk women who have had erythroblastotic children.

5. Others -- not of much medical significance at present

A. Lutheran
B. P
C. Lewis
D. Duffy
E. Levay
F. Graydon
G. Tobbins
H. Secretor

Reference: Race and Sanger. Human Blood Groups.