Multiple Alleles

We have been talking a great deal about "alleles" and by now a clear understanding of the meaning of the gene and its alleles must have been acquired. A gene can exist in several alternative forms. These alternative forms are called alleles. Alleles occur in pairs, and are located on identical spots (loci) on the homologous chromosomes. Although, in the diploid individuals, only two alleles are present, it does not mean that there are only these two alleles for a particular character. There can be more than two alleles of a gene; as many as 20 or even more in some cases are reported in the literature. These sets of alleles are called "Multiple alleles".

Every new allele arises as a result of gene change (mutation) somewhere in the ancestral line. It will be interesting to note that if there had been no mutated genes, it would have been rather impossible to determine the genetic basis of inheritance of characters. Members of an allelic series affect almost the same trait. The criteria for the identity of a multiple allelic series are (i) the heterozygote should phenotypically resemble either of the parent or be intermediate between the two parents and (ii) alleles must segregate out into separate gametes producing 3:1 or 1:2:1 phenotypic ratio in the F_2 generation.

Members of the same multiple allelic series are conventionally designated by the same basic letter symbol and each allele being identified by a specific superscript or subscript.

We shall now consider a few cases where more than two alleles have been reported:

(i) Rabbits have several alleles for their coat colour. The coat colour may be:

1. Full colour (grey or black body) (CC).

2. Chinchilla (traces of yellow lacking) $c^{ch}\ c^{ch}$

3. Himalayan (only extremities are coloured and the rest of the body white) $(c^{h}\ c^{h})$

4. Albino (no colouring at all) (cc)

The existence of these four alleles for coat colour in rabbits can be confirmed by making crosses between any two of them and obtaining the typical monohybrid ratio. This is how they behave in such crosses:

Cross I

	(coloured)	CC × cc	(albino)
F_1		Cc	(all coloured)
F_2		3 C–	(coloured)
		1 cc	(albino)

Cross II

	(coloured)	C C × $c^{h}\ c^{h}$	(Himalayan)
F_1		Cc^{h}	(all coloured)
F_2		3 C–	(coloured)
		1 $c^{h}\ c^{h}$	(Himalayan)

Cross III

	Himalayan)	$c^{h}\ c^{h}$ × c c	(albino)
F_1		c^{h} c	(all Himalayan)
F_2		3 c^{h}	(Himalayan)
		1 cc	(albino)

From these data it is clear that three different forms of coat colour in rabbits are determined by the three alleles of the gene for this character (coat colour). Full colour is dominant over Himalayan and albino; Himalayan is dominant over albino. Crosses of these individuals with the ones having chinchilla coat colour have shown that chinchilla is recessive to full colour, but dominant over the other two, i.e., Himalayan and albino.

The four rabbit colours for their phenotypes and genotypes are shown as under:

Phenotype	*Genotype*
Full colour	CC, $C c^{ch}$, $C c^{h}$, Cc
Chinchilla	$c^{ch} c^{ch}$, $c^{ch} c^{h}$, c^{ch} c
Himalayan	c^{h} c, ^{h} c^{h} c
Albino	cc

Similarly, in the drosophila, the colour of eye which is a sexlinked character is controlled by many alleles. Quite a large number of shades of the eye colour may be observed, each dependent upon a separate allele. There may have been reported more alleles for the eye colour in drosophila. Red eye colour is the wild form, and is dominant over all the other alleles, while different combinations among the mutated forms show intermediate dominance.

Phenotype	*Genotype*
Red	W W
White	w w
Wine	$w^{w} w^{w}$
Coral	$w^{co} w^{co}$
Blood	$w^{bl} w^{bl}$
Eosin	w^{e} w^{e}
Cherry	$w^{ch} w^{ch}$
Apricot	w^{a} w^{a}
Buff	$w^{bf} w^{bf}$
Tinged	w^{t} w^{t}
Ivory	w^{i} w^{i}
Pearl	w^{p} w^{p}
Honey	w^{h} w^{h}

Blood groups in man

When a foreign substance called antigen (protein) is introduced in the body, it stimulates a reaction resulting in the formation of antibodies in the blood serum. Antibodies are a type of protein, and when produced react with the antigen and destroy it. As a result of this reaction, the blood cells agglutinate (clump) and thus block blood circulation in the blood vessels of the recipient, causing death.

In man, blood groups are controlled by multiple alleles. There are four kinds of blood groups according to the type of antigen present named group A, group B, group AB and group O. Persons having blood group A will have antigen A in his cells, but no antibody against this antigen. Similarly, persons with blood group B will have antigen B and no antibody against B. When an antigen is not present in the blood cells, the corresponding antibody is present.

The following shows these relationships:

		Blood contains		Reaction with antibodies	
Group	Genotype	Antigens	Antibodies	Anti. A.	Anti. B.
A	$I^A I^A$, $I^A i$,	A	Anti.* B	Positive	Negative
B	$I^B I^B$, $I^B i$,	B	Anti. A	Negative	Positive
AB	$I^A I^B$	AB	None	Positive	Positive
O	i i	None	Anti. A Anti. B	Negative	Negative

*Antibodies

It is noted that the four blood groups in man are due to combination of three multiple alleles and are inherited in a Mendelian fashion. Each antigen is due to a dominant gene and a blood group may be homozygous or heterozygous. The heterozygotes will produce two types of antigens. The gene responsible for A type of blood group is symbolised as I^A and for O blood group as i the former is dominant over the latter. An A type individual may be homozygous ($I^A I^A$) or heterozygous ($I^A i$).

Similarly, gene I^B for blood group B is dominant over i gene and the individuals of the group B may be I^B i or I^BI^B. A B blood group type has only one genotype, $I^A I^B$, they are codominant and both express themselves in the same individual. O type blood group persons always have homozygous recessive genotype (ii).

Transfusion of blood between two persons is possible only if they have compatible blood groups. The parenthood of babies may also be established by the study of the blood groups, in certain situations.