



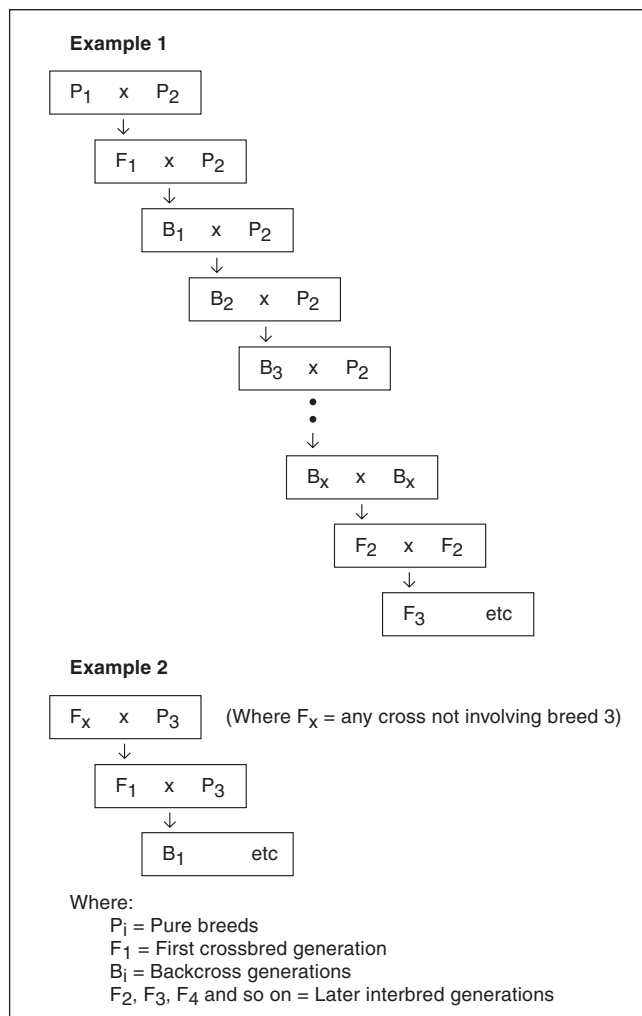
## Genetic nomenclature and animal breeding terms

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### Genetic nomenclature

In animal breeding programs where purebred lines are maintained, naming of the succeeding generations is simple - they are always purebred. However, where crossbreeding is a part of the system, naming the generations that comprise different proportions of genes from each original purebred can become quite complex.

The diagram below describes the accepted naming system for different crosses. Note that 'P' always means purebred, 'B' always means backcross to one of the original breeds and 'F' always means a hybrid or interbred hybrid.



The use of standard naming systems ensures that everyone understands what is meant by each term.

### Animal breeding terms

**Alleles** Alternative genes at a particular position on the chromosomes. Alleles produce different effects on the same trait – for example, horns vs polls.

**Assortative mating** Like-to-like matings. Matings between animals with similar characteristics. Non-random mating. See disassortative mating.

**Backcross** A backcross occurs if, following a cross between two breeds, the progeny (or later generations) are mated to one of the original breeds. For example:

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    Breed 1 x Breed 2
    ↓
    First cross (F1) x Breed 2
    ↓
    First backcross (B1)
  
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**Breed** A defined population of animals within a species that differs from other populations in respect of genetically determined traits.

**Breeding value** The additive effect of all genes that affect a trait. The value of an animal as a parent to its progeny in terms of a trait, expressed as a genetic deviation from the average of a population.

**Breeding objective** A statement of traits that are to be improved, to which is attached estimates of their relative economic value. The traits must be heritable and have economic value.

**BLUP** (Best Linear Unbiased Prediction). A sophisticated statistical software program that geneticists use to estimate breeding values of animals.

**Combining ability** The performance of a line in crosses with another line; contains both additive genetic and heterosis effects.

**Correlated characters** Traits that change together, either in the same or different directions; for example, as fibre diameter of wool increases, fleece weight also increases on average. This is an example of a positive correlation.

**Diploid** Nucleii with a full set of paired chromosomes; that is, double the haploid number. Characteristic of most animal cells except the gametes (sperm and ova).

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**Disassortative mating** Matings between unlike individuals.

**Dominance** A gene that causes the same effect whether it is present as a single or double copy (heterozygote or homozygote).

**Epistasis** An interaction between non-allelic genes, where one gene suppresses or enhances the effect of the other.

**Estimated breeding value (EBV)** Breeding value estimated from the phenotype of an animal. Expressed as a deviation from the average of a population.

**Expected progeny difference (EPD)** The expected deviation of the progeny, based on the performance or EBV of its parents.

**Full-sibs** Individuals with both parents in common.

**Generation interval** The average age of the parents when their progeny are born.

**Genetic correlation** (Symbol  $r_g$ ) Correlation between breeding values. Used to estimate the change that will occur in trait 2 in the progeny when the parents are selected on trait 1.

**Genetic standard deviation** (Symbol  $\sigma_g$ ) The standard deviation of breeding values (see Standard deviation). Related to the phenotypic variance ( $\sigma^2_p$ ) and heritability ( $h^2$ ) as follows:

$$\sigma_g = \sqrt{(h^2 \times \sigma^2_p)}$$

**Genetic variance** (Symbol  $\sigma^2_g$ ) The variance of breeding values.

**Genome** The set of chromosomes contained in the nucleus of each cell of a species. A haploid nucleus has a single genome.

**Genotype** The particular collection of genes possessed by an individual.

**Genotype x environment interaction** A change in ranking of, or difference between, genetic groups under the influence of different environments. Caused by the switching on and off of different gene sets within a genotype.

**Genotypic value** The sum effect of the genes possessed by an individual to itself. *Also see* breeding value.

**Group breeding scheme** A breeding system in which there is a two-way flow of genetic material between tiers. Commonly, sires migrate downwards from ram breeding flocks, while a proportion of the upper level ewe requirements are drawn from lower levels.

**Half sibs** Individuals with one parent in common.

**Haploid** A nucleus that contains a single set of unpaired chromosomes.

**Heritability** (Symbol  $h^2$ ) The scale of this statistic is 0 to 1. The proportion of the total variance that is genetic in origin. The heritability that we are generally concerned with in animal breeding is that caused by the additive effect of genes. The heritability determines the degree of resemblance between relatives. It is calculated as the ratio of the genetic variance to phenotypic variance.

**Heterosis** See hybrid vigour.

**Heterozygote** Having different genes at corresponding positions on the chromosome pairs. For example, the term P is used for polledness in sheep, p for horned. A heterozygote for this position would have Pp as its two genes at this loci.

**Hierarchical structure** A breeding structure where there is a one-way flow of genetic material; for example, the traditional Merino structure, where rams are distributed downwards. Often a registration barrier prevents upwards migration.

**Homozygote** Having identical copies of genes at the corresponding loci on chromosome pairs; for example, PP (see heterozygote).

**Hybrid** The offspring of matings between parents that are genetically different. Usually only refers to the first cross ( $F_1$ ).

**Hybrid vigour** Deviation in performance from the average of unlike parents. Reversal of inbreeding depression. Also called heterosis

**Inbreeding** Matings between parents that are more related by ancestry. May be matings between closely related individuals.

**Incomplete penetrance** Proportion of animals carrying a gene that display the expected characteristic; for example, in the recessive gene for pigment spots, only about 25% of homozygotes actually display pigmentation, instead of 100%.

**Indirect selection** The process of causing change in a character by selecting for a correlated trait; for example, using greasy fleece weight as a selection criterion to improve clean fleece weight.

**Linkage** The tendency for groups of genes to be inherited as a unit. Linked genes lie near each other on one chromosome.

**Locus** Position on a chromosome.

**Mass selection** Individual selection.

**Maternal effect** Pre- and post-natal environmental effect of the dam on her offspring. In sheep breeding, the important maternal effects are age-of-dam and birth/rearing status.

**Monozygous twins** Genetically identical animals.

**Mutation** Sudden change in the chromosomes. Where this occurs in the gametes, the result may be an aberrant organism with an evolutionary advantage, leading to permanent population change.

**Mutant** An organism that is the result of mutation.

**Natural selection** Change in populations caused by the selection pressure of a changing environment. Certain individuals may have an adaptive advantage and therefore be reproductively fitter.

**Nicking** Special combining ability of some breeds in crosses, or of some pairs of individuals when mated together.

**Normal distribution** A frequency distribution describing the frequency of types varying from the average in a population. Many biological variables have approximately normal distributions.

**Nucleus breeding system** A breeding system where an elite group of animals is selected to form a top tier, usually to breed males; characteristic of group breeding schemes, but can also be incorporated into hierarchical structures.

**Panmixia** Random mating.

**Penetrance** Proportion of animals carrying a gene which display the expected characteristic. Complete penetrance occurs when all animals display the expected phenotype.

**Phenotype** The observed physical appearance, the sum effect of genetic and environmental influences.

**Phenotypic correlation** Correlation between observed values. Used to predict the effect of indirect selection in the current flock.

**Phenotypic variance** Variance of observed values.

**Pleiotropy** Multiple effects from one gene. One of the main causes of genetic correlations.

**Polygenes** Genes acting together to produce the phenotype, but which individually have very small effect. Important in determining quantitative characteristics.

**Progeny test** A method of estimating the breeding value of a parent from the performance of its offspring.

**Qualitative trait** Traits inherited in discrete classes; for example, horned or polled, black or white.

**Quantitative trait** Traits inherited by degree; for example, weight, height, wool weight. Quantitative traits are usually distributed normally (see Normal distribution).

**Random mating** Every male in the reproducing population has an equal chance of mating with any female. In practice, generally means random assignment of females to males.

**Recessive** A gene that has no effect on phenotype unless it is in the homozygous state; that is, one copy on each chromosome (see heterozygote).

**Relative economic values** Economic values that are attached to traits in the breeding objective. They take account of estimates of future product market values and the number of expressions on the trait during the animal's lifetime.

**Repeatability** The tendency for animals to maintain their ranking with time; for example, for the top fleece weight sheep to remain the most superior with age. Scale from 0 to 1.

**Selection, artificial** Selection applied by man. Can lead to the impairing of the animal's adaptation to its environment.

**Selection differential** The difference between the average of the selected group and that of the whole group before selection; or, the superiority of the selected group. A measure of the selection pressure applied.

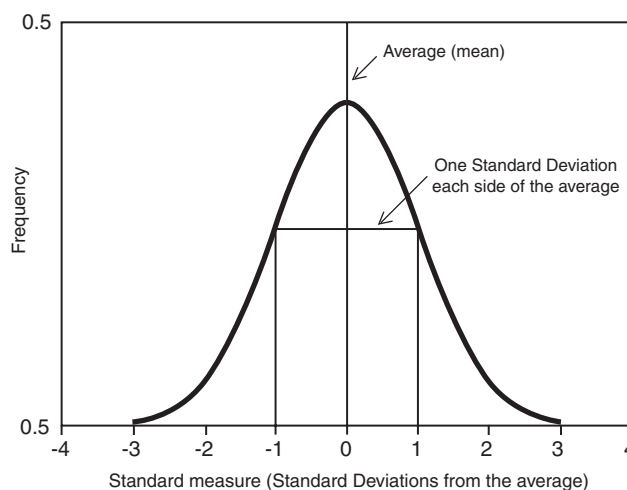
**Selection criteria** Those characteristics that are measured (or assessed) as predictors of the traits that are to be improved.

**Selection index** A method of combining information on several characteristics into a single figure that is used as a selection criterion.

**Selection intensity** Selection differential expressed in standard deviation units.

**Selection limit** Expectation is that selection will eventually lead to genetic fixation as favourable alleles occupy all loci. The total possible progress is  $2N$  times the progress possible in the first generation, where  $N$  is the effective population size. Bottlenecks in response are not uncommon, but a true selection limit has not been observed in cattle or sheep. Genotype x environment interactions can be the cause of bottlenecks.

**Standard deviation** (Symbol  $\sigma$  for the parameter (true value),  $s$  for its estimate) A measure of the spread of individual observations about the average. One  $s$  is the range from the average to each point of inflection on the normal distribution, and the range from  $-1s$  to  $+1s$  is expected to contain about 68% of the observations (see Normal distribution).



**Tandem selection** Selection applied to one trait at a time until trait targets are reached.

**Trait 1.** Any definable characteristic. 2. A production component in a breeding objective.

**Transmitting value** See Expected Progeny Difference.

**Variance** (Symbol  $\sigma^2$ ) The square of the standard deviation. The variance of the sum of two variances is the sum of the variances; that is, variances are 'additive'.

**Variate 1.** A characteristic that has a value for each member in the population. 2. A measured component in a selection index.

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