# Basic Genetics

By

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# Why Breed?

- **Before you breed a litter**

  - know why you are doing so,

  - what you wish to achieve.

- **Understand the basics of genetics and the problems within your breed.**

- **In contemplating a litter** , know-

  - breed worth of the parents

  -their overall breed soundness (relative to that breed).

- **When breeding dogs -trying to create better and hopefully sounder dogs.**

# Breed Soundness

Breed soundness is determined by assessing several areas:

- 1. **Physical soundness**. - relates to construction and health. Is the animal fit for function, fit for life?
- 2. **Mental soundness**. - refers to the temperament, ability and aptitude of the animal to be of benefit in its chosen field.
- 3. **Genetic soundness**. reflected in physically obvious attributes, as well as on cellular and hormonal levels. The means to readily remove these conditions from a breed are often not yet available.

## Breed Soundness cont…

- 4. **Breed type.**

  -is your dog or bitch typical of the breed.

  - ideally above average in order to improve the quality of stock within your kennel.

**The overall picture** covers many aspects within each area and may have different slants within various breeds.

***Compromises*** often have to be made when balancing out the relative importance of different problems both within that animal and the breed as a whole.

# General Genetics

- Every time you select a dog to breed to your bitch, you are practising the art (or science) of genetics.

  It is important to at least try to understand the basic principles of genetics and the laws of inheritance.

  An understanding of genetic principles can assist your comprehension of what is happening and what might happen when you mate two dogs.

Basic definitions:

- ***Genes*** are the basic components of the genetic material that is passed on from generation to generation.

  A gene is composed of DNA and in effect is the blueprint of information to the cells.

  If the gene is defective or missing then the information controlled by that gene will also be defective or missing.

  Genes can overlap in effect and only if the missing gene is controlling a very specific or life threatening process, will the lack of that gene be noticed.

## Basic Definitions cont….

- ***Chromosomes*** - Genes are connected to each other on long strands called chromosomes. Chromosomes are 'paired', with one chromosome of each pair coming from each parent.

  Every ***species*** has a distinct number of chromosome pairs, which never varies within that species.

  Dogs have **39 pairs**. Similar species tend to have very close or identical numbers of chromosomes.

  The dog, wolf, dingo, coyote and the jackal have the same number of chromosomes.

- The dog has a large number of chromosomes for a mammal.

  The larger the number of chromosomes, the ***greater the amount of possible re-combinations of the genetic material***.

- This large number of chromosomes and the enormous variations that are possible has allowed the dog in all its numerous shapes, sizes and breeds, to spread and adapt to so many different climates and conditions throughout the world.

Basic Definitions…

- ***Mitosis*** is the process of cellular division and replication of the chromosomes. The chromosomes individually 'self copy'; and at cellular division, each daughter cell gets an identical set (and number) of chromosomes.

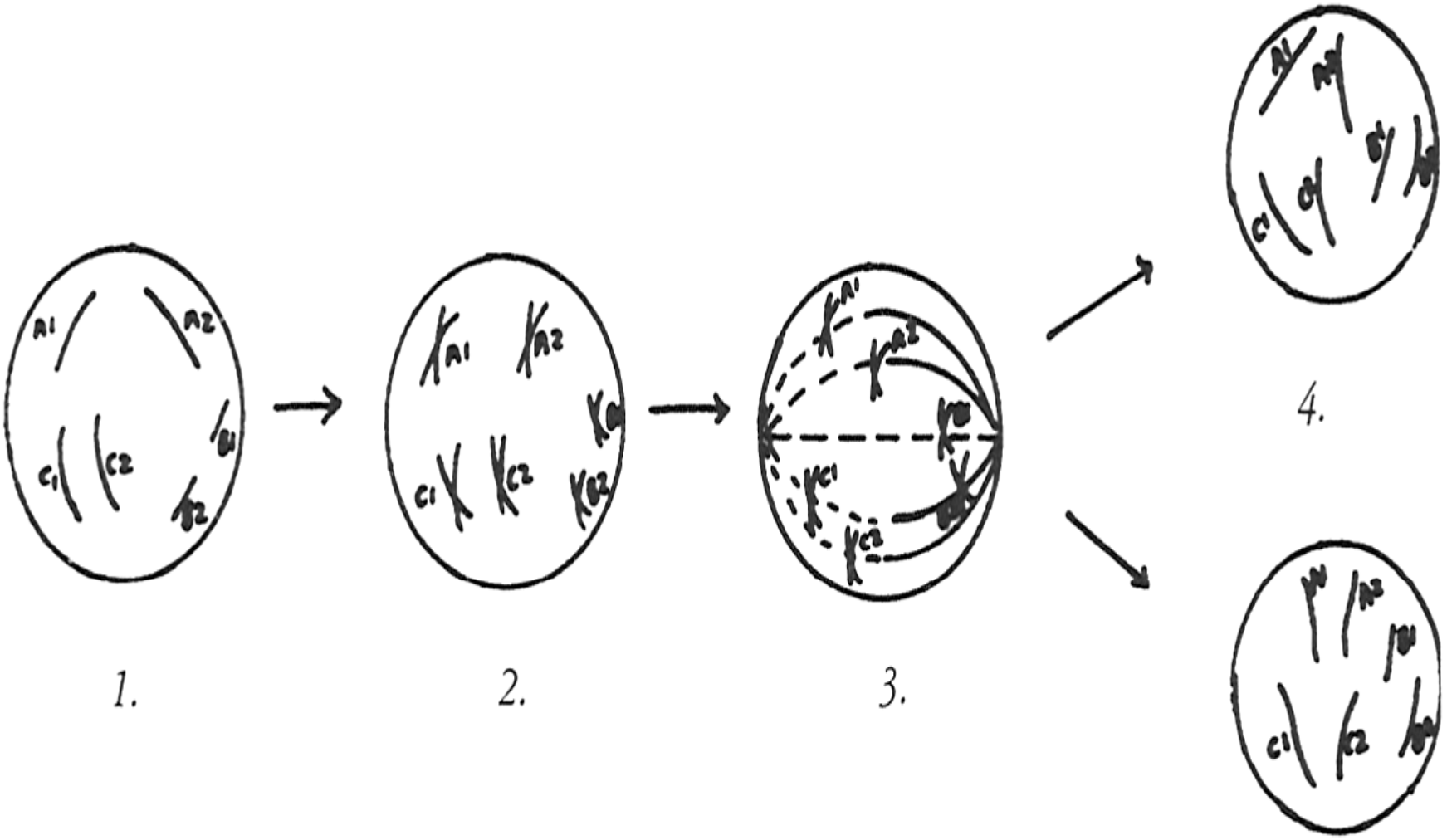
  This is the way that the body cells are produced during growth or replace worn out or damaged tissues.

- **Meiosis** is the process where the chromosomes come together as pairs (and undergo recombination) and then divide so that the each new cell has only half the 'pair' of the chromosomes.

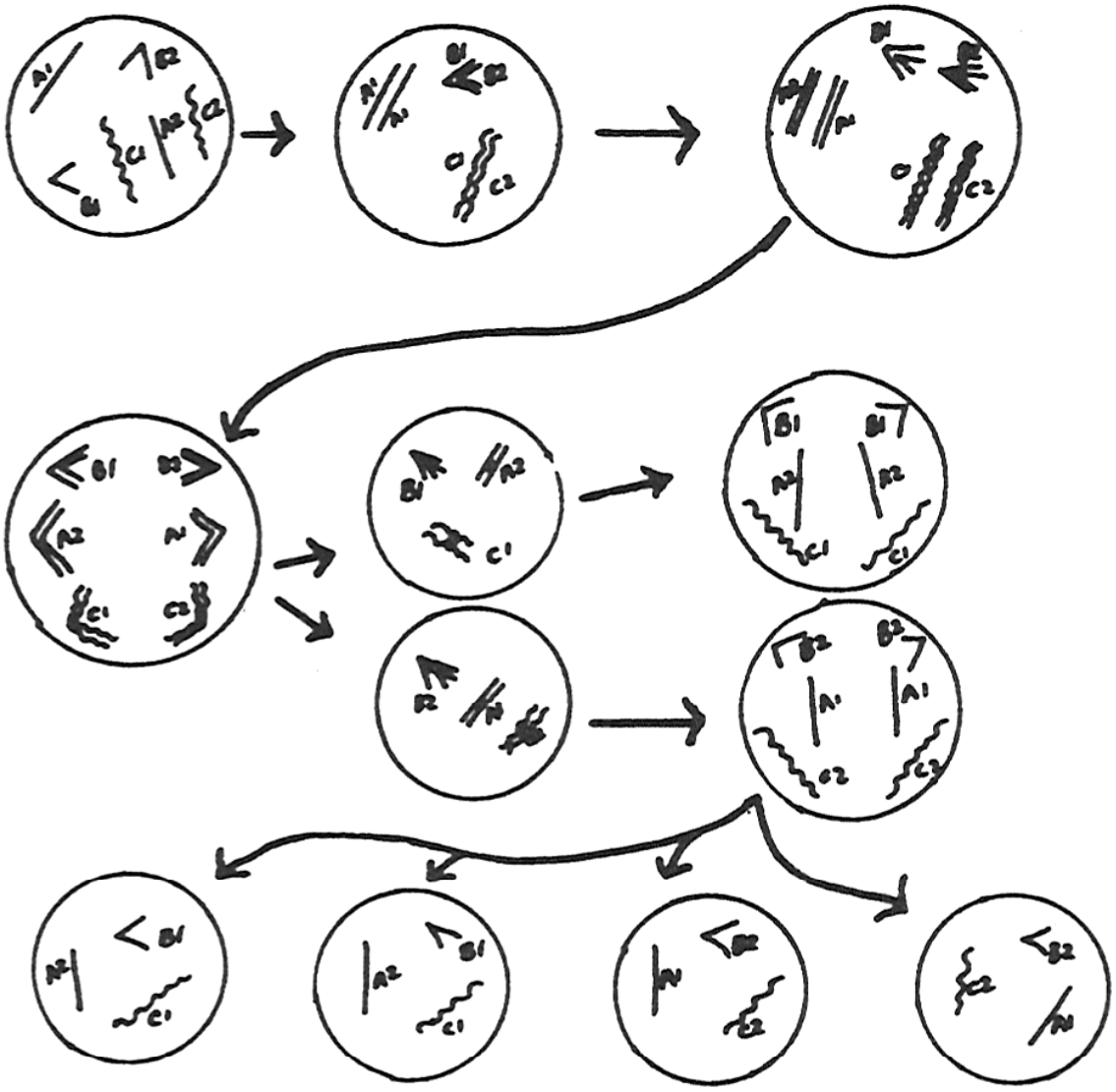
  Upon fertilisation, the original number of chromosomes is restored. This only takes place in the 'germ' cells - the ova and the sperm.

- It is important to realise that this is the time that the ***chromosome linkage and recombinations*** are made that allow the incredible variation between individuals (even within litters) to occur. Recombination allows a random re-shuffling of the hereditary characteristics.

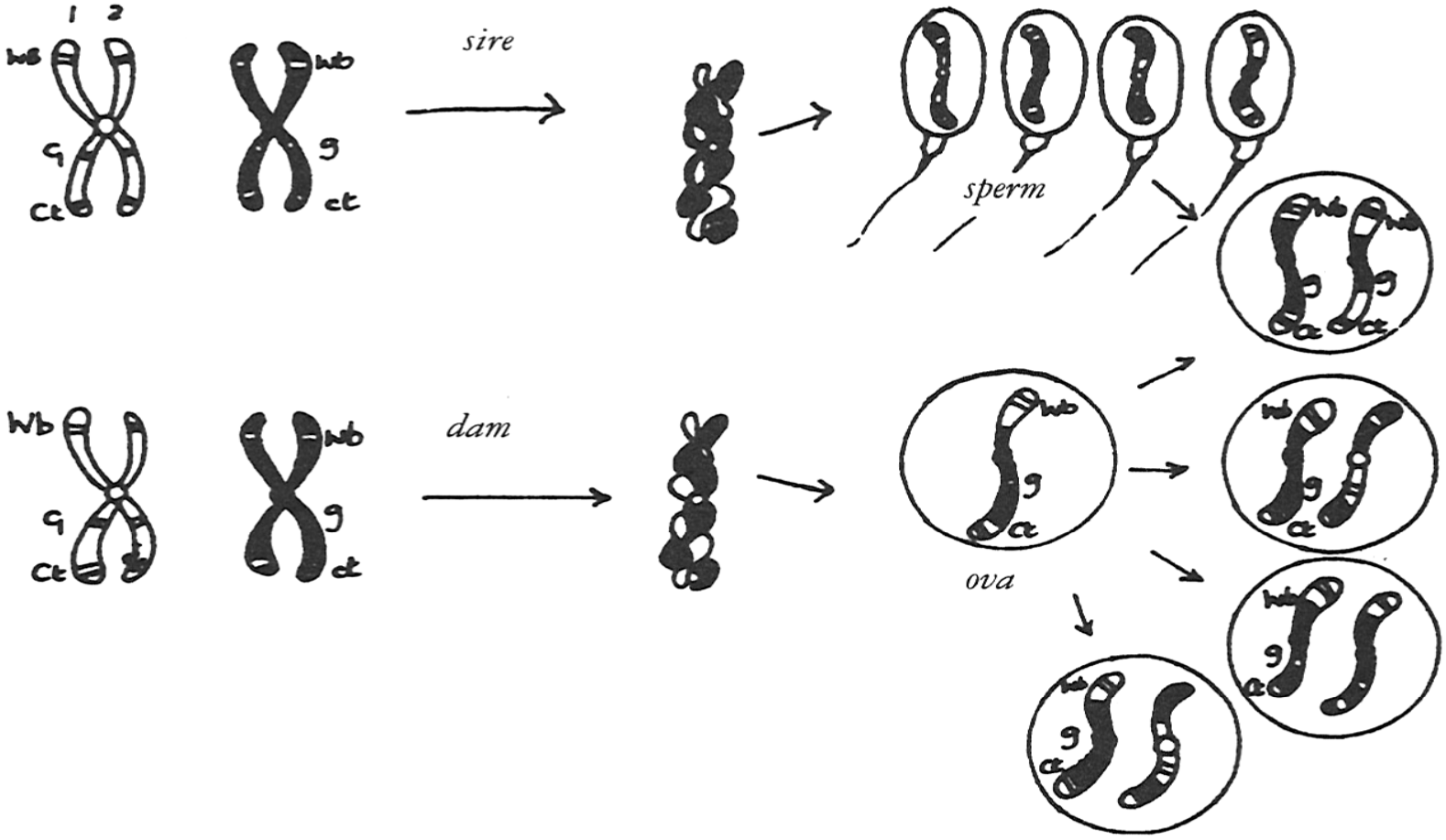
# Cell division (mitosis)



# Sex division (meiosis)



# Linkage and Recombination




Linkage and Recombination — during meiosis

Definitions continued…

- ***Alleles* -** are slightly different forms of the same gene. Different alleles cause variations such as in coat colour.
- **Homozygous** - If the allele is the **same** on both chromosomes then the animal is ***homozygous*** for that gene – ie. it can only throw that allele to any progeny.
- **Heterozygous** - If the alleles are **different** on each chromosome, then the animal is said to be ***heterozygous*** for that gene ie. either allele can be passed on to the progeny.

# Definitions cont…

- **Dominant** - An allele which, when present in **a single dose**, still manages to produce its full effect upon the animal is said to be a ***dominant*** allele.
- **Recessive** - An allele which has its effect blocked or masked by another allele is a ***recessive*** allele – it is only expressed if present in 2 copies.
- Occasionally, when there are several alleles for a gene, it is possible to have an allele which is dominant to one allele, yet recessive to another, for example coat colour in many breeds.

**Dominance** etc……

- ***Incomplete dominance*** of an allele can result in the apparent 'blending' of the effects of the dominant gene with the recessive gene.

- ***Incomplete penetrance*** of an allele is where the dominant allele does not exert its full effect upon all the animals that carry it.

  This allows some which carry the dominant gene, not to show it in external appearance. The percentage of animals which show the character they carry in their genes is termed the penetrance of the gene.

# Sex determination…

## Sex Determination: Males are XY
## Females are XX

- **The Y chromosome** carries all the differences that are between the sexes and it also means that sex determination is made by the male.
- **Sex linked**. Some characteristics more common in one sex. Sex linked characteristics are mostly seen in the male as the character is usually carried on the X chromosome. This means with only a single X present in males, certain otherwise recessive characteristics can be expressed.
- **Sex determined.** Only animals of that sex can exhibit the characteristic eg. testicular abnormalities are only seen in the male.

Definitions still…

- **Genotype** describes the genetic make-up (or blue-print) of an animal ie. It's genetic potential.
- **Phenotype** means the actual physical make-up, or what we see physically. 'Phenotypically' much of an individual's genetic make-up is not visible, but the genetic potential will become more obvious through the offspring. Phenotypical appearance can be greatly affected by the environment.

## Polygenetic…

- **Polygenetic** means more than two genes affect a characteristic or function. Genes can work in a group, with a cumulative effect. The interaction between the genes makes the understanding of genetics of these groups very difficult, particularly the larger the number of genes involved.

  Many genes that inter-relate as far as function or metabolism is concerned. There are thought to be at least 4-5 genes involved in hip dysplasia making this a difficult problem to try and eradicate as a phenotypically normal animal is not necessarily genetically 'free'.

# Interaction Between the Genetic Make-up of an Individual and the Environment

- The environment is anything which has an effect on the development of the individual.
- The genetic material that is passed on at the time of fertilisation is the total sum of the parental genetic contribution. The environment can affect the development of the foetus in the uterus, and then the puppy, as affected by the level of maternal care and the impacts of the physical world.
- The main environmental factors affecting the post-natal development are diet and temperature. How the individual is affected by these depends on its innate genetic constitution.

# Interaction cont.

- Extremes of temperature, inadequate food and mineral deficiencies can cause stunted growth and increased susceptibility to disease. Given adequate food, the growth is then largely dependent on the genetic constitution of an individual.

- Some characteristics are not affected at all by the environment eg. basic colour and coat patterns.

- Polygenetic characters such as hip dysplasia are more affected by environment than are the simple recessives as there are more factors that can be influenced by the environment eg. diet, rate of weight gain and exercise.

# Difference Between Congenital and Inherited

- ***Congenital*** means present at birth, 'something went wrong' at some stage of development during pregnancy. Congenital defects can be genetic ***or*** as the result of accidents during development.
- Development of the foetus occurs rather like an assembly line that is highly complex and has many processes going on at the same time. Occasionally the right 'button' or correct sequence does not occur and an abnormality will result.
- These abnormal 'happenings' can occur spontaneously (mutations), due to genetic make-up, or can be the result of external influences (these are not passed on to future generations).
- *External influences* can be many and varied eg. the effect of some drugs such as Thalidomide which causes abnormal shortening of limbs or Tetracycline, an antibiotic which if used during pregnancy can cause permanent damage to the enamel of the teeth.
- External influences include any environmental factor eg. periods of excessive heat. A heatwave lasting several days can cause all sorts of congenital abnormalities, particularly towards the end of the first trimester of pregnancy.

## Difference Between Congenital and Inherited cont.

- Excessive body temperature elevation due to a viral and/or a bacterial disease, particularly if it occurs during the crucial time towards the end of the first trimester of pregnancy, may cause a similar assortment of abnormalities.

  The first trimester of pregnancy is the time when the most rapid developmental changes are taking place, cells are particularly 'sensitive' to outside changes at this time.

  Remember that the main point about a ***congenital defect***, is that *it is not necessarily genetic* ie. passed on to future generations.

- There are congenital defects which have a genetic basis, such as cleft palates and hare lips in some particular breeds (eg. Papillons) but not all breeds.

**Difference Between Congenital and Inherited cont.**

- ***Inherited*** This is the genetic material that is passed on to the next generation unchanged by, although the 'expression of' may be altered by, the environment.

- When selecting matings for factors that have few alleles affecting them (eg. coat colour), it is fairly easy to predict the resulting colours of the offspring.

- The more genes affecting a characteristic, the harder it is to eradicate. Where there are ways to measure the effect of the characteristic, then progress can be made eg. X-raying of individuals and their progeny for hip dysplasia.

**Determining whether a fault or defect is inherited:-**

- 1. Does it affect more than one member of a litter? Obviously the larger the litter the more likely you are to get a significant result.
- 2. Has it recurred in a repeat mating, or in matings that are genetically similar?
- 3. Are there ancestors in common?
- 4. Test breeding can be carried out to see if the fault reappears (last resort!).

## Breed Selection –
## Selection of Breeding Partners

- Actual selection of animals for breeding is done by several methods with many differing aims in mind by the various breeders. The traits considered desirable in one country, may not be particularly sought after in another.

  Breed preferences and aims do change over the years.

  Gradual changes within breeds and lines are desirable when aiming at improvements in soundness or working ability.

# Selection for Desirable Traits

- Breeders try to select the more desirable characteristics of the breed, but some of these characteristics may well have variable methods of inheritance.

  Some characteristics have fairly well documented genes, so that you can plan with reasonable accuracy (colour etc).

  As time goes on, and more characteristics are sorted out genetically, the breeder will be better able to predict what a proposed mating will produce as far as type, colour or shape.

# Selection against Undesirable traits (faults)

- When trying to select for desirable characteristics, you are at the same time trying to reduce or eliminate the undesirable characteristics.
- Where the fault is a simple recessive, it is relatively easy to reduce the incidence of it in your lines, but unless there is a simple DNA test to determine the carriers, the fault can be very difficult to completely eradicate.
- Breeders and clubs with the long term interests of the breed at heart are setting up schemes to test for the worst genetic faults (ie. those that are detrimental to the health, comfort and mobility of the animals) and reduce the incidence of these faults.
- The more breeders participate in such schemes, the quicker the overall standard of the breed will improve.

# Selection Potential

- Selection potential is a term that appears every now and again, and refers to how 'heavily' an animal is selected for breeding compared to the rest of the population.

  This usually refers to the reduced number of individuals, particularly males, which end up being bred versus the total male population available.

  With males, because they can have multiple offspring at one time (ie. a litter) and can reproduce at a comparatively early age, a fairly high selection potential can apply.

- When selecting a puppy in a litter, a breeder usually has 4-6 puppies. This means that rapid genetic 'improvements' are possible. With the smaller breeds, there is usually a small litter size as well, so the rate of genetic improvement is slower.

- What this means in real terms to a breeder is that as far as stud dogs are concerned, there is a very high selection potential on the exceptional males. Only about 10% of male dogs are used at stud, compared to about 40-50% of the bitches used for breeding.

## Selection Potential cont…

- In the long run, ***a few males*** will end up having a fairly large effect on the breed, whereas a bitch has to be heavily bred from and be an exceptional producer to have the same effect.

  A well used stud dog can produce 60-80 puppies during the same time as a bitch is producing one litter of 6-8 puppies.

- Before you decide to breed your bitch or dog, make sure that she/he is a relatively sound animal in type, temperament and structure.

  If there are major genetic faults within your breed, at least try to discover them ***before*** breeding your bitch or allowing your dog to be used at stud.

- As stated earlier, determine why you wish to breed a litter from that animal. Ideally you want to breed a better dog for yourself, but the litter should also be as sound as you can make it for the sake of all the other owners of the puppies from that litter.

# Different Types of Matings

There are several different types of mating systems that are used; quite often two or more systems are used simultaneously.

- **1. Type to Type Matings**

  Where the body and structure of both parents are similar in type. Generally one parent is the better animal (usually the dog), and you are attempting to correct minor faults while still retaining the same general body type.

  This system works well, particularly if the parents are 'typical' of the litters/lines from which they came.

- **2. Corrective fault matings**

  Where the 'types' of the parents are not necessarily similar, but one parent is particularly good in various areas while the other parent is weak.

  The resultant progeny will range in type between both parents, as will the fault you are trying to correct. This type of mating is generally done when trying to upgrade the quality of your stock.

# 3. Inbreeding and “Line breeding”

*Inbreeding and line breeding* are often thought to be totally different types of matings by many novice breeders.

- **Inbreeding** is generally considered by the older breeders to be close or incestuous breeding, whereas **line breeding** is thought to be where the common ancestors are slightly further removed.

  ***It is all one and the same thing, only the degree varies.***

- *Inbreeding* (*or line breeding)* is where an animal appears more than once on a pedigree.

  If this occurs after the fifth generation, the effect is negligible.

  The animal being ‘doubled up’ or inbred upon should be a very superior individual, having qualities which hopefully he/she transmits strongly. By inbreeding on this animal, or set of animals (eg. a particular set of litter mates), you are trying to set or fix a type.

# Inbreeding and linebreeding cont.

- *Genetically, you are trying to make the offspring homozygous for certain features, so that the offspring will:*

  (a) Exhibit the desired characteristic.

  (b) Reproduce the characteristic consistently.

- *Inbreeding of any degree results in the doubling up of an individual's genetic makeup*. As you double on the good points, you double your chances of producing the bad points, which may have been hidden until the individual was inbred upon.

- Homozygosity - As more points become homozygous, your 'type' will stabilise, **but *the potential for change is reduced***, as are the factors that affect survival and reproduction (inbreeding depression).

Inbreeding and linebreeding cont.

- ***The effects of heavy inbreeding include:-***

  (a) Reduced litter size in bitches; reduced percentage of viable (normal) sperm in males.

  (b) Reduced survival rate; offspring are more susceptible to infections or changes of climate. The ability to adapt to these changes is reduced by too many factors becoming homozygous i.e. both parents have donated the same form of the gene, therefore the ability to change is reduced.

  (c) Reduced lifespan for the same reasons as above.

  (d) Decreasing mental stability as the animals become more and more highly strung or neurotic.

Inbreeding and linebreeding cont.

- ***To summarise, inbreeding is useful in helping to establish a type and should be done only on exceptional individuals.*
- *If grave faults appear on a regular basis, do not continue.*
- ***For the average breeder, the best results of inbreeding (line breeding) generally occur using the third and fourth generation ie. grandparents and great-grandparents.***
- Once should avoid first generation inbreeding on the whole (father/daugther; mother/son, full litter mates), as it is very high risk breeding.

# Types of matings continued..

- **4. Outcrossing**

  Outcrossing is where new bloodlines are introduced into a pedigree. No common individuals appear in the first 5 generations.

  Outcrossing enables new genes and gene combinations to occur.

  With outcrosses, the first generation produced may appear to be a loss as far as the show ring is concerned. The value is often seen in the next generation, when they are crossed (not too closely) back into either parent's line.

- **5. Line Combinations**

  Line combinations are where certain bloodlines 'nick' well together. The lines do not necessarily have to be inbred in themselves. They may either be sire lines, or less commonly, bitch lines. When this occurs, the lines 'blend' together favourably.

  Good combinations are generally based upon exceptional sires or brood bitches with an effect that extends through their descendants.

Types of Matings cont…

## 6. Prepotent dogs and bitches

These animals are generally those exceptional producers, whether male or female, whose effect continues beyond their own generation.

Prepotent dogs or bitches always throw their own type, whatever dog or bitch that they are put to.

Prepotent can occasionally refer to particular virtues or faults that a dog or a bloodline produces with characteristics showing up in the majority of the offspring.

*Prepotency* is held to be a very good sign in a stud dog.

# Prepotent dogs and bitches cont.

- The **best sires** are those that come from a very strong female family as well as a good male line, particularly if both are fairly prepotent animals. This way the sire should produce reasonably good results, even to the poor and mediocre bitches.

- The ***best brood bitches*** *are those that come from prepotent bitches of strong family type*. Occasionally sires may not produce an outstanding male, but the bitches from this sire may be of very good type and soundness and go on to produce offspring far above expectations.

  These sires are known as brood bitch sires and, while their male line may not persist, the effect of the sire is carried strongly through their daughters.

# Summary

- Dedicated dog breeders must become 'relative' experts in many areas if they wish to produce sound healthy dogs, as well as understanding the problems within their breed.

- ***Beautiful, healthy dogs who are sound in temperament and body, are the aim of all dedicated dog breeders.***

  Where definitive tests exist that reduce the incidence of disease and/or improve soundness within the breed; breeders and breed clubs must try to incorporate such disease testing where feasible.

- The more we know of all the factors affecting our breeding stock (construction, inherited diseases) before breeding a litter, the better equipped we are as breeders to find solutions to problems and hopefully reduce the number of unsound dogs being produced. It has benefits for all, particularly for the dogs.

**** Remember when breeding, aim for soundness and reliability as the age of guarantees is upon us. Lawsuits abound!***