Genetics: the Breeder's Blueprint

by Jill Swedlow

The days of the large breeding kennels are gone. In their 'time' Marydane, Dinro and other large kennels, set the standard for others to reach in their breeding programs. Most breeders today (2011) have 2 or 3 Danes and occasionally breed their bitch. They are unable to delve deeply into line breeding with the goal to create a 'line' that breeds true. To do this one needs to breed many dogs, many times, and then pick, choose and cull accordingly. This no longer happens due to lack of space, and in my case anyway, no desire to maintain any type of kennel. My dogs are my pets first, show second and breeding stock third.

So why bother with genetics? Like it or not, genes hold the high cards when it comes to producing good quality (or poor quality) Danes. I don't claim to be a genetic expert, but I do understand the basic principles. Even though I don't feel I'll ever establish a 'line' that breeds true, I do tend to opt for a certain 'type' when choosing breeding pairs. I think this accounts for the general 'look' of my dogs.

Genes also control multiple diseases that affect our Danes and all breeders need to be aware of what these diseases are. They should further be willing to share their knowledge with the fancy in general in order to help eliminate these problems. A basic knowledge of how genetics work is helpful.

The following is only my attempt to explain the workings of basic genetics in a language that may be comprehensible to my fellow laypersons. It seems that once things like recessive and dominant are fully understood, the rest becomes much more understandable. Jill]

Once the basic principles of genetics are learned and understood, it becomes an invaluable tool to breed improvement. It helps you to understand why certain traits that were not seen in the conformation of the parents can turn up in the conformation of the offspring. You no longer feel as if you are groping blindly in the dark in your quest to improve your dogs.

I do not intend to delve too deeply into how the sperm and ovum carry the genes or the mechanics of microscopic reproduction. This subject can be learned from many good texts written for the layman in comprehensible terms. If you have little or no knowledge of these facts, you should learn your basics as it will give you a better understanding of the information contained in this section. I have included my own basic descriptions in that, without some knowledge of reproduction, you will not understand the following concepts. Mainly I intend to explain how genetic understanding can be used to accomplish your breeding goals and how I use it.

The Importance of a Pedigree

When planning a breeding, the more informa-tion you have about each parents relatives, the more accurately you can predict what traits that particular animal is likely to pass on to its offspring. The ancestral names, which appear on a pedigree, have no value unless you have specific information about as many individuals as possible. Try to actually see as many of the ancestors as you can. Evaluate each one in terms of conformation, health and temperament and what they have produced if applicable. Keep a file on each dog, either on your computer (my method) or on hard copies so you can refer back as needed. Photographs or videos are also extremely helpful.

If you cannot see the animal in person, interview those who have. Ask them as many questions as you can think of about each dog. The more information you accumulate, the more accurate will be your ability to predict what to expect in the litter.

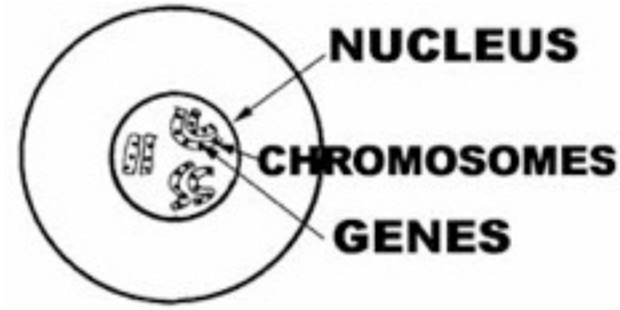
The Mechanics of Inheritance

Some elementary genetic principles must be illustrated here in order to understand what follows.

The new pup inherits half it’s genes from its sire and half from its dam. The genes are the chemical blueprint which determines every inherited physical characteristic each pup in the litter will have. They determine his size, color, whether his back is long or short, whether his head is pretty or common, on and on for every part of his body inside and out.

There are two types of cells in the dog, as in other living organisms. The body cells, known as SOMATIC cells, which make up all tissues of the body such as skin, internal organs, bone, etcetera. These somatic cells differ from the sex cells in that they carry a full compliment of the animals genetic material, 78 CHROMOSOMES in the case of the dog. The GENES reside upon the chromosomes. The sex cells, called GAMATES, are the sperm cells in the male dog and the egg cells, or ova, in the bitCh. The gametes carry only ONE HALF the chromosomes of the somatic cells. Since the genes are found contained within the chromosomes, this means that the gametes only have one half the genes ofthe body cells. This seems to be the most difficult concept for the beginning student of genetic inheritance to grasp so I have included the following illustrations to help clarify this point.

The following illustration, is of a SOMATIC CELL (body cell). It contains the nucleus which contains the 64 pairs of chromosomes, which contain the genes. (Only 3 pairs of the dog's chromosomes are shown for the sake of clarity).

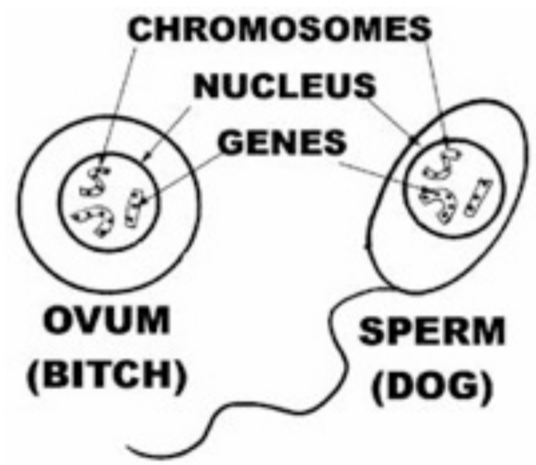


Dominant and Recessive Genes

Without going into deep technical detail it is important to understand the basic concept of dominant and recessive genes. This is probably one of the greatest points of confusion among those who breed animals but have little knowledge of genetics. Because of these traits, there occurs a phe-nomenon whereby an individual may carry genes to express a specific trait (genotype) but the trait is not expressed physically (phenotype). Let me be more specific. Genotype is simply a word that refers to the actual genetic makeup of the individual; it's the sum total of a particular genetic makeup. You may or may not actually see the physical trait controlled by a certain gene(s). Phenotype is the physical body that you can actually see and measure, such as fawn coat color or a bad bite. It is the proof that an animal really does carry a gene to control the trait. At the risk of being redundant, a trait controlled by recessive genes can often be hidden by a dominant gene, but a dominant gene always is expressed physically (pheno-typically).

I wish to mention here that for the sake of clarity, I have purposely left out discussion of modifiers, complete and incomplete dominance, masking genes etcetera. Not only would they tend to muddy the water of understand-ing the basics, which is difficult enough, but they are always a handy scapegoat to use if the unexpected occurs in a breeding. "Oh well, the stud must have carried masking genes and modifiers!", you can state wisely. It is also worth mentioning here that, unfortunately, there are very few inherited traits, which are attributable to only one gene. Most traits are made up from several genes interacting with each other. In order to understand these principles though, it is necessary to use the simple dominant and simple recessive traits.

I will use fawn and brindle coat color as an example since it is an easy trait to see and understand. It is also inherited in a straight forward way and is controlled by one gene. The gene which produces the brindle pattern in Great Danes is dominant to fawn. The gene which produces a fawn colored coat, is recessive to the brindle gene. Since brindle is the dominant gene, a Dane showing this pattern as his phenotype can still carry the fawn color gene recessively as part of his genotype. Remember I stated that each parent carries two sets of genes and chromosomes but gives the offspring only half their chromosomes, thus half their genes.



	B	f
B	1 B B	2 Bf
f	3 B f	4 f f

The fawn bitch (who carries only fawn genes) donates one of her two recessive fawn genes, the brindle dog [who, for the sake of this example is a homozygous brindle, which means he carries only brindle genes and is himself, brindle] donates one of his dominant brindle genes. Their offspring carries one gene for each color as his genotype but his phenotype can never be fawn because the brindle gene is the dominant one of the pair. Now we have a whole new set of genes. What happens if this new individual, who carries both a fawn and brindle gene (making him genetically heterozygous which means he carries a gene for each color), is mated to a bitch who is genotypically identical to him? This means that she carries the same genetic makeup for fawn and brindle, being phenotypically brindle.

There is no certain way to predict exactly how the genes will combine unless you are dealing only with animals that are homozygous for the pure dominant or recessive trait. In other words, a mating between a brindle dog and a brindle bitch, both of whom are homozygous for the brindle gene can produce nothing but brindle offspring all of whom are genotypically homozygous for brindle and all of whom are phenotypically brindle. A dog which is homozygous for such a trait, is said to "breed true" for that trait. (If you are getting confused here, be sure you understand the meaning of homozygous (both genes for said trait are the same), heterozygous (carries genes for both traits, fawn and brindle), genotype (what the genes actually are) and phenotype (the actual appearance of the body pattern).

Square 1 shows the color expectancy from the above proposed mating of the heterozygous brindle dog and bitCh. Let "B" represent the dominant brindle gene and "f" represent the recessive fawn gene. (The geneticists do it a bit differently, but this will be clearer for our purposes). This average is based on over 100 offspring.

We will now take each square of the graph individually. Each square represents a pup, it’s genotype and phenotype for the fawn and brindle genes.

Square and Pup #1

This pup's genotype (BB) contains 2 genes for brindle. His coat color is brindle. He can pass on only brindle genes to his offspring since he is homozygous for the brindle gene and does not carry a fawn gene recessively.

	B	f
B	1 B B	2 Bf
f	3 B f	4 f f

Squares and Pups #2 & 3

	B	f
B	1 B B	2 Bf
f	3 B f	4 f f

These pup's genotypes (Bf) each contain one gene for brindle and one for fawn. Their coat colors are brindle. They can pass on either the brindle or the fawn gene to their offspring since they are heterozygous for brindle and fawn. Since the fawn gene is recessive to brindle, it is not able to express itself in the pup's phenotypes.

	B	f
B	1 B B	2 Bf
f	3 B f	4 f f

Square 4 & Pup 4

This pup is our example of two recessive genes finding each other and expressing a genetic trait of its parents, which the parents did not show in their phenotype. This pup's genotype (ff) contains two genes for fawn color. His coat color pattern is fawn. He can pass on only fawn genes to his offspring since he is homozygous for fawn. If he carried a brindle gene, he would appear brindle since brindle is dominant to fawn.

The chart is a shorthand method of calculating the probability of any two genes finding each other at the moment of conception. The heterozygous male has sperm, half of which carry a fawn gene and half of which carry a brindle gene. The heterozygous bitch has ova with the same makeup, half carry the fawn gene and half carry the brindle. It is pure chance as to which sperm finds which egg. The laws of probability tell us however, that in a sampling of 100 offspring, approximately 25% will be BB, (homozygous for the dominant brindle gene with a brindle phenotype). 25% will be ff, (homozygous for the recessive gene for fawn coat color, with a fawn phenotype). And 50% will be Bf, (heterozygous for fawn and brindle with a brindle phenotype).

I have taken you through all the above in order to more clearly explain the behavior of simple dominant and recessive gene pairs. Since the chromo-somes occur in pairs in the somatic cells, so do genes. I'm going to continue with the example of the fawn gene versus the brindle gene. As previously stated, these traits are controlled by single genes (not multigenetic as are most traits, unfortunately for us!) and brindle is dominant to fawn.

When gametes (sex cells) are formed, they contain only 1/2 of the genetic make-up of each parent. One gamete may end up with the gene which causes brindle stripes, and the other gamete may carry the other gene for fawn body color. The same will be true of the male's sperm cells. It is pure chance as to which of the bitch's ova becomes ripe first and ovulates into the fallopian tubes to await the dog's sperm. It could be one with the fawn gene or one with the brindle gene. Since there are an equal number of each, there is a fifty-fifty chance of it being either. The same holds true of the dog's sperm. Approximately one half of the millions of sperm contained in each ejaculate carry his fawn gene, and one half carry the brindle gene. If the sperm which fertilizes the ova carries a gene for fawn, and the ova has the gene for brindle, the pup will be born brindle since brindle is dominant to fawn. The resulting pup will carry one gene for brindle and one for fawn and is, itself, genetically capable of producing get of either color depending on the genetic make up of it's mate. If the bitch's ova happens to be one with the gene for fawn, and so is the dog's sperm, the pup will be fawn and carry two genes for fawn. If the bitch's ova carries the brindle gene and so does the dogs sperm, the pup will not only be brindle but will carry brindle in a double dose (both genes brindle, eg. homozygous) and can NEVER produce any get except brindle since brindle is dominant to fawn.

The laws of probability tell us that with animals carrying simple recessive and simple dominants, the chances are always 50-50 as to which gene is inherited by the pup. The calculations are over the expectancy of 100 offspring so if your brindle dog has been bred to 3 fawn bitches and has produced 15 brindle pups, there is STILL a 50-50 chance that the next litter he sires could contain fawns. A small chance, but still a chance. This will also tell you something about his genotype. You know he carries a recessive gene for fawn because he has produced fawn pups even though he is himself brindle. You also know that he carries the dominant brindle gene because he is brindle.

Sometimes semantics seem to be responsible for some misunderstand-ing. One breeder once asked me why her brindle dog sometimes produced fawn pups instead of always producing brindle pups if the brindle gene was dominant. She didn't understand that the gene had to be passed along to the pup (inherited) in order for it to be able to exert it's dominance. The chances of the brindle gene being passed along, when the dog carries a recessive gene for fawn as well, are 50-50. Only dogs who are homozygous for the brindle gene (they have 2 genes for brindle and carry no gene for fawn) will produce 100% brindle pups.

Admittedly the above examples are overly simplified when compared to multigenetically controlled traits. There are other types of genes which behave in different ways. In order to predict accurately the expectancy of certain traits, you must have a pretty good idea of the mode of inheri-tance.

The example of canine coat color can be translated into many traits of Great Danes. Brindle is dominant to fawn but there are other colors (and patterns) in the breed that are not quite so simple to understand and predict. The relationship between genes, which is dominant to which, and which are recessive, can be likened to a pecking order among chickens. The rooster (most dominant gene) is at the top of the heap and bosses everyone around. Next is the bossiest hen who only takes orders from the rooster. Below her are the rank and file of her subordinates, all of whom obey their betters, and in turn, control their underlings until you come to the bottom of the heap and find the little hen (most recessive gene) whom everyone picks on. She never gets to eat or express herself until she is the only one in the barnyard.

Now you are probably beginning to wonder how any of this can be helpful since little is known of the mode of inheritance of many canine traits. Also, few traits are controlled by a single gene. Most are multigen-etic, such as head shape. There are probably thousands of genes and their modifiers which make up the blueprint which determines the shape of a dog's head. Although it would be very difficult, not to mention impractical, to try isolating each gene and how it behaves in creating the overall blueprint, these controlling groups of genes often tend to act in recessive or domi-nant ways as a group. For instance, let us say you have a dog with a beautiful head. You mate him to 10 bitches whose head type ranges from ugly to plain, but none are gorgeous. If 75% of the offspring have beautiful heads like their sire, you can be fairly accurate in concluding that your dog is dominant for his head type. This can be applied to any conformation trait or group of traits which tend to occur in the same manner. But what about traits which, as a group, behave in a recessive manner? Since recessives are masked by dominants, they can be difficult to isolate. (The recessive genes often control undesirable traits such as an undershot jaw or light eye color).

We will use an undershot jaw (the lower teeth protrude forward of the upper) as our example. Assume you breed a bitch and dog to each other who both possess a correct bite. Some of their puppies are undershot. What does this tell us? It is highly probably that both parents are carriers of the recessive gene, or genes, which produced the bad bite. (Remember the brindle dog and bitch who both carried fawn recessively and produced a fawn pup?) We are dealing with the same principle here. What makes a trait like this difficult to breed out is it's recessive nature. Their pups could as easily have had a correct bite but still carried the genes for a bad bite recessively. These recessives can be masked by their dominant alleles (genes which appear on a common location on the chromosomes) for generation after generation until the time when they pair with another like recessive and express themselves in the puppy's phenotype. If you will refer back, once again to the charts, you will see that there is a 50% probability that an offspring of recessive carrier parents will itself be a carrier.

This is a rather sobering thought, especially when one realizes that such recessives can skip generations and the individual must be test bred in order to ascertain if it is, indeed, a carrier. So what is the logical solution to this problem? Intelligent breeding practices and ruthless culling, which will be discussed later.

There are several different methods of planned breeding used by knowl-edgeable breeders. All have their good points and their drawbacks. Sometimes one must simply experiment with the different methods to establish which will work best under any given circumstances. This, then, brings us to a discussion of inbreeding, linebreeding, and outcrossing.

Inbreeding

Inbreeding is generally considered to be the closest type of breeding possible. Full brother to full sister, mother to son and father to daughter. Ironically, an occasional sister/brother mating may not be genetically close at all since the possibility exists for each sibling to have received entirely different sets of genes from each parent. This is, however, seldom the case and we can assume it to be inbreeding for our purposes.

Those who do not understand genetic principles often condemn in-breeding, claiming that it weakens the animal which it produces. In many cases this can be true, but inbreeding itself is not the culprit.

By its very nature inbreeding gives the greatest probability that recessive genes will be expressed. This is because closely related animals are more likely to carry the same recessives in their geno-type than unrelated animals. By breeding these close relatives to each other the chances are high that two recessive genes, or groups of recessive genes, will meet and produce the trait they control in the animal's phenotype. Inbreeding's poor reputation is due to the fact that traits which are controlled by recessive genes are often undesirable, such as light eyes or incorrect mouths. If the trait they control is desirable, then inbreed-ing is considered to be successful, but you usually get some of eaCh.

Inbreeding can be a very useful tool for pinpointing an animal's genotype. When inbreeding is employed, it is safest after linebreeding has set a type and you have related dogs who consistently produce the qualities you have been striving to "set" in your breeding line. You should have a very clear idea of what your gene pool is capable of producing and then use only animals whose phenotype is as nearly perfect as possible. Even then it can be risky, but if successful, you have a real prize. Inbreeding should be a tool held only in the hands of a knowledgeable breeder, it is definitely not for the novice.

Line breeding

This practice usually includes pairings such as, niece to uncle, grand child to grand parent, half sister to half brother or a pairing which includes one animal's name somewhere within the first three gen-erations on both sides of the pedigree. Linebreeding is probably the safest approach when establishing a breeding line. Although recessives can certainly be expressed when using this method, the frequency is not as high as with inbreeding. There is a wider margin for error here because progress is more gradual.

As with inbreeding, you must be sure to use only superior quality individuals when linebreeding. You must also be certain that the ancestor being linebred on is himself or herself a superior specimen of the breed, and has the traits you are trying to set in your line. If you linebreed on faulty animals, you're more than likely going to get faulty pups. You must also be sure not to breed two animals together who have faults in common. In other words, if the dog is a bit cowhocked, make sure that the bitch is perfect in her rear legs.

Outcrossing

This is the mating of unrelated animals who do not have any ancestors in commoun within the first 4 or 5 generations. Unlike inbreeding and line-breeding, this method will do nothing to make the resulting pup more homozygous genetically. It is very difficult to predict with any accuracy what results might be obtained from such a mating unless the outcross mate is, himself, line bred. The continued use of this breeding method will never produce a group of animals which breed true for any characteristic.

One advantage of this method is that you are less likely to encounter any recessive genetic problems unless the parents each carry these genes.

Outcrossing can best be used when, after several generations of line-breeding you have established a gene pool which breeds true most of the time for the traits you desire, but you find that your gene pool does not contain genes for producing, for example, a beautiful head. You will try to locate a stud dog, who is from a linebred family with beautiful heads, and who has himself consistently produced pups with beautiful heads. Even though this animal himself is the result of linebreeding he is unrelated to your own animals and the resultant breeding is considered an outcross. Then you take the good headed results of this mating and breed it back to your own linebred bitches. You have now obtained the genes you need to work with in order to put beautiful heads on your future puppies.

Besides the above outlined breeding techniques, there are several others. I will not go into them here, but many breeding books can fully explain them to you. Much can be learned from books concerned with breeding other types of animals such as horses, cattle and chickens. The principles are identical.