Practical Genetics for Samoyed Breeders and Owners

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Breeding Samoyeds

As a breed, the AKC registered Samoyed population has significantly declined over the last fifteen years. Individual dog registrations were at 8,192 in 1985, making the Samoyed the 29th most populous breed in registrations. While registrations grew to 8,389 in 1990, the breed rank dropped to 36th most populous, due to the rising popularity of other breeds. By 1995, AKC registrations were less than half, with 4,088 dogs being registered, and a breed rank of 47th. The decline in registrations has continued each year, with 2,552 dogs registered (54th) in 1998 and 1,698 dogs registered (66th) in 2001. These numbers have to be compared to what is going on with the SCA "breeder" population versus the commercial breeding population. Sometimes the popularity of a breed based on commercial, puppy mill, or pet-store breeding can drop, but the gene pool represented by the individual breeder/club member does not change accordingly.

There are ways to measure the genetic diversity and health of a population. One method is to measure the average inbreeding coefficient for a breed. The inbreeding coefficient is a measurement of the genetic relatedness of the sire and dam of a dog. All individuals inherit pairs of chromosomes, one from the mother, and one from the father. On the chromosomes are genes; so all genes come in pairs. If both genes in a gene pair are the same gene (for instance, "aa" or "AA") the gene pair is called homozygous. If the two genes in a gene pair are unlike (for instance, "Aa") the gene pair is called heterozygous. If a dog appears on both the sire and dam's side of the pedigree, it increases the inbreeding coefficient of the dog. The inbreeding coefficient also provides a measurement of homozygosity.

The non-variable gene pairs in a breed are all homozygous, and allow the dogs to breed true. This is why two Samoyeds bred together always produce a Samoyed, and not a chicken. The variable gene pairs in a breed produce the variation you see between dogs in the breed. The inbreeding coefficient gives a measurement of the total percentage of variable gene pairs that are expected to be homozygous due to inheritance from ancestors common to the sire and dam. It also gives the chance that any single gene pair can be homozygous.

When computing inbreeding coefficients, you have to look at a deep pedigree to get accurate numbers. I prefer to use 10-generation pedigrees, which require a computerized pedigree database to compute. Looking at the historical pedigrees of (non-commercial) Samoyed breeding dogs, we find that for dogs born in the decade 1950-1959, the average ten generation inbreeding coefficient was 17.14% +/- 8.65%. For Samoyeds born 1970-1979, this number is 12.04% +/- 8.24%. For 1990-1999, the average inbreeding coefficient is 9.94% +/- 7.64. These numbers show that your breed is utilizing the diversity of pedigree background available, and not breeding itself into a corner of the gene pool. This suggests that your breed has acceptable overall breed-wide diversity.

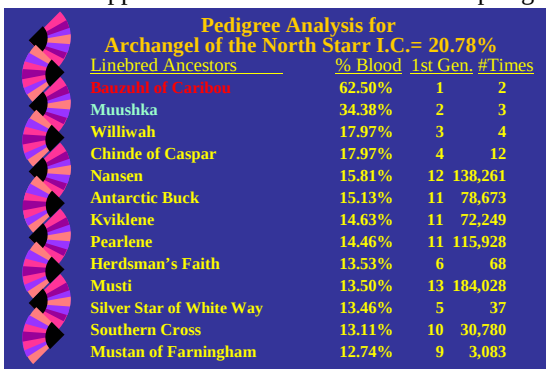
Pedigree Analysis of Individual Samoyed Dogs

Archangel of the North Star has a 10 generation inbreeding coefficient of 20.78%. He is more tightly bred than the average Samoyed. Studying his pedigree shows that his sire is also his maternal grandsire, making his pedigree a father x granddaughter mating. Based just on the father x granddaughter relationship, this provides an inbreeding coefficient of 12.5%. The additional 8% of the inbreeding coefficient represents contribution of the other dogs that appear in both the sire and dam's side of the pedigree.

The relationship coefficient, which can also be approximated by what is called the *percent blood* coefficient, represents the probable genetic likeness between the dog whose pedigree is being studied, and a particular ancestor. It is a measurement of the average percentage of genes the individual and the ancestor should have in common.

The following is a pedigree analysis of Archangel of the North Starr. The sire, Bauzuhl of Caribou has a 62.5 percent blood coefficient: 50% as the sire, and 12.5% as the maternal grandsire. Muushka and his dam Williwah have high percent blood coefficients, as they appear three and four times respectively in the

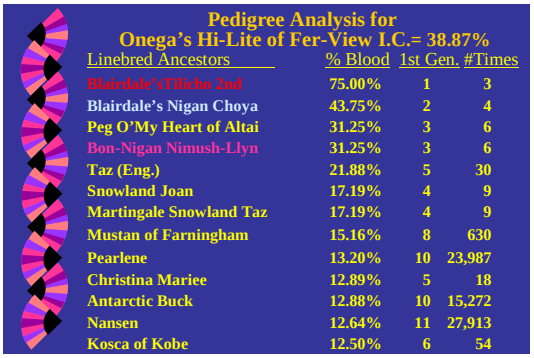
pedigree. For a dog to be influential in a pedigree, it has to appear behind more than one offspring. Otherwise, you are only linebreeding on the single offspring, and only the 50% of genes that were passed on by its parent.



Pedigree Analysis for
Archangel of the North Starr I.C.= 20.78%

Linebred Ancestors	% Blood	1st Gen.	#Times
Bauzahl of Caribou	62.50%	1	2
Muushka	34.38%	2	3
Williwah	17.97%	3	4
Chinde of Caspar	17.97%	4	12
Nansen	15.81%	12	138,261
Antarctic Buck	15.13%	11	78,673
Kviklene	14.63%	11	72,249
Pearlene	14.46%	11	115,928
Herdsman's Faith	13.53%	6	68
Musti	13.50%	13	184,028
Silver Star of White Way	13.46%	5	37
Southern Cross	13.11%	10	30,780
Mustan of Farningham	12.74%	9	3,083

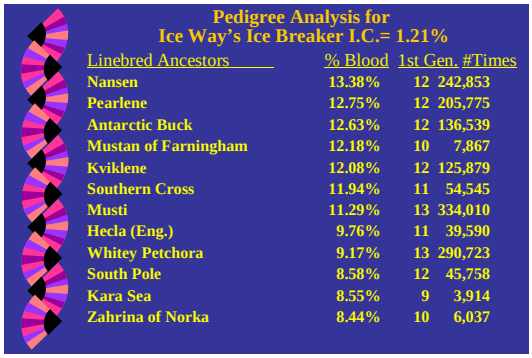
Chinde of Caspar appears 12 times in the pedigree, starting in the fourth generation. Even though one appearance in the fourth generation only contributes 6.25% of the genes to a dog, because he appears 12 times, he contributes almost 18% of the genes to this pedigree. Nansen is the first ancestor that provides what I call the background inbreeding in the pedigree. He doesn't appear until the 12th generation, but appears 138,261 times, providing almost sixteen percent of the genes to the pedigree. Such founding ancestors provide what is called the background inbreeding, and are what established the pedigree base for the breed. If an influential ancestral dog carried a detrimental recessive gene, it would be widespread in the breed. The rest of the linebred ancestors in the pedigree are listed in the pedigree analysis.



Pedigree Analysis for
Onega's Hi-Lite of Fer-View I.C.= 38.87%

Linebred Ancestors	% Blood	1st Gen.	#Times
Blairdale's Tilicho 2nd	75.00%	1	3
Blairdale's Nigan Choya	43.75%	2	4
Peg O'My Heart of Altai	31.25%	3	6
Bon-Nigan Nimush-Llyn	31.25%	3	6
Taz (Eng.)	21.88%	5	30
Snowland Joan	17.19%	4	9
Martingale Snowland Taz	17.19%	4	9
Mustan of Farningham	15.16%	8	630
Pearlene	13.20%	10	23,987
Christina Mariee	12.89%	5	18
Antarctic Buck	12.88%	10	15,272
Nansen	12.64%	11	27,913
Kosca of Kobe	12.50%	6	54

Onega's Hi-Lite of Fer-View is the result of a father to a double maternal granddaughter mating, with a 10 generation inbreeding coefficient of 38.87%. Blairdale's Tilicho 2nd is the sire, and the grandsire on both sides of the dam's pedigree, with a percent blood contribution of 75%. Blairdale's Nigan Choya contributes 43.75% of the genes to the pedigree, however, 37.25% of these are the genes he contributed as the sire of Blairdale's Tilicho 2nd. Obviously, this pedigree is a tightly bred, or inbred pedigree. If detrimental recessive genes are shared by the parents of such matings, you can see increased numbers of affected dogs from such matings.



Pedigree Analysis for
Ice Way's Ice Breaker I.C.= 1.21%

Linebred Ancestors	% Blood	1st Gen.	#Times
Nansen	13.38%	12	242,853
Pearlene	12.75%	12	205,775
Antarctic Buck	12.63%	12	136,539
Mustan of Farningham	12.18%	10	7,867
Kviklene	12.08%	12	125,879
Southern Cross	11.94%	11	54,545
Musti	11.29%	13	334,010
Hecla (Eng.)	9.76%	11	39,590
Whitey Petchora	9.17%	13	290,723
South Pole	8.58%	12	45,758
Kara Sea	8.55%	9	3,914
Zahrina of Norka	8.44%	10	6,037

Ice Way's Ice Breaker is an outbred dog, with a 10 generation inbreeding coefficient of 1.21%. The only common ancestors between the sire and dam in the pedigree are those that provide the background inbreeding for the breed, and don't appear until the eighth generation. The most influential dog in this pedigree is Nanson, who doesn't appear until the 12th generation, but appears 242,853 times, and contributes as much as a great-grandparent.

Genetic Diversity Issues

Some breeders concerned with breed-wide genetic diversity propose only assortative mating and outbreeding to those least related. Assortative mating is breeding based on the phenotype, or appearance of the dog. Breeders should always use assortative mating by breeding like-to-like to solidify the traits that their dogs have, and breeding like-to-unlike to bring in traits that they desire.

Linebreeding is breeding dogs more closely related (a higher inbreeding coefficient) than the average of the breed, and outbreeding involves breeding dogs less related than the average of the breed. Linebreeding tends to increase homozygosity. Outbreeding tends to increase heterozygosity. Linebreeding can expose deleterious recessive genes through pairing-up, while outbreeding can hide these recessives. Outbreeding can prevent dogs affected with recessively inherited disorders due to heterozygosity. It does not eliminate the recessive gene, as the gene is propagated in carriers. Neither type of breeding alters the frequency of individual genes, just how they are distributed in the offspring. Selection, and not the types of matings used affect breed genetic diversity.

If two parents are both heterozygous (both Aa) for a gene pair, on the average, they would produce 25% AA, 50% Aa, and 25% aa. (These are averages when many litters are combined. In reality, any variety of pairing up can occur in a single litter.) If a prolific stud dog comes out of this litter, and he is homozygous aa, then the frequency of the "a" gene will increase in the population, and the frequency of the "A" gene will decrease. This is known as the popular sire syndrome. Of course, each dog has thousands of genes that vary in the breed, and everyone carries some deleterious recessive genes. The overuse of individual breeding dogs contributes the most to decreased diversity (population bottlenecks), and the increased spread of deleterious recessive genes (the founders effect).

Genetic diversity in a breed means breeder diversity. It is the varied opinion of breeders as to what constitutes the ideal dog, and their selection of breeding stock that maintains breed diversity. If some breeders favor a certain line of dogs, and other breeders favor different lines, then that maintains diversity. If someone breeds one line, and wants to outbreed and bring in genes from another line, that maintains diversity. Breeders should select the best from their breeding programs to maintain the quality of the breed. Selecting mediocre dogs, just because they are unrelated is not desirable. The first and foremost goal is always to produce quality dogs.

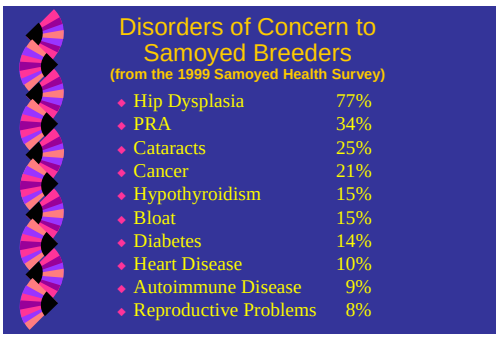
Attempting to continually outbreed to maintain diversity is a self-limiting practice. If everyone outbreeds, then eventually, there will not be any "unrelated line" to be found. Everyone will have a mixture of everyone else's genes. The fallacy of using outbreeding to maintain genetic diversity is the belief that the diversity of a breed must be maintained in every single dog. Breed diversity requires breeders that maintain different linebreeding programs of quality dogs. Then a healthy breed-wide mix of linebreeding and outbreeding involving quality dogs, without an overabundance of single dog contributions, maintains diversity. For more information on breeding, see "The Ins and Outs of Pedigree Analysis, Genetic Diversity, and Genetic Disease Control" at www.compuped.com/bell.asp.

Health Concerns

To develop a healthy breeding program, you must choose your breeding stock, and their mates carefully. As stated above, the primary goal of dog breeding is to maintain and enhance the quality of the breed. You are not breeding a hip, a thyroid, or an immune system; you are breeding Samoyeds. Conformation, temperament, working ability, and health must all be balanced in your selection. (See the article, "Choosing Wisely" in the April 2000 AKC Gazette for a more in depth discussion.)

The breeding goal of managing genetic disorders involves firstly, the prevention of affected dogs. Then, the goal is to decrease the (carrier) frequency of deleterious genes in the breeding pool. According to the AKC Canine Health Foundation, the most frequently occurring genetic disorders across all breeds are; epilepsy, hip dysplasia, hypothyroidism, cancer, bloat, heart disease, autoimmune disease, allergies, progressive retinal atrophy (PRA), patella luxation (slipping kneecaps), allergic (atopic) dermatitis, cataracts, and other eye diseases.

According to the 1995 Samoyed Club of America National Health Survey, hip dysplasia is the genetic disorder of the most concern to Samoyed owners and breeders, with 77% citing it. The rest of the list is similar to those disorders cited among all dog breeds, with the exception of diabetes mellitus. Disorders listed by body system and frequency show that orthopedic disorders are the most frequent problems, followed by female reproductive problems, cancer, eye problems, endocrine disorders, skin, gastrointestinal, kidney, neurological, heart, behavioral, and blood disorders.



The actual frequency of individual disorders could not be discerned from the published health survey information. The most frequent orthopedic disorder reported in the Samoyed is hip dysplasia, including 27% of all dogs with a reported orthopedic disorder. Hip statistics from the Orthopedic Foundation for Animals (OFA) rank the Samoyed 71st among 126 breeds, based on

12,220 radiographs. This places the Samoyed in the middle of the pack. 9.2% of Samoyeds are rated excellent, 62.9% good, 15.6% fair, and 11.6% dysplastic. Of those rated dysplastic, 5.6% were mildly dysplastic, 5.1% moderately dysplastic, and 0.9% severely dysplastic. We consider OFA dysplasia statistics to be less than the actual frequency in the breed, as owners tend not to send in radiographs that show obvious dysplasia. However, compared to other breeds of the Samoyed's size and body type, these statistics are fairly average.

The second most frequent orthopedic disorder reported in the survey is arthritis, including 23% of dogs reporting an orthopedic disorder. To evaluate this properly, we would need to know the average age and range of ages of dogs reporting arthritis. Other orthopedic disorders reported in the health survey occur at a small frequency.

The OFA statistics show 4.3% of Samoyeds with elbow dysplasia, ranking them 30th out of all breeds based on 349 radiographs submitted. 73% of the affected dogs have Grade I dysplasia, 27% have Grade II dysplasia, and no dogs were found with Grade III dysplasia; the most severe form. Grade I elbow dysplasia is a radiographic disorder, usually showing no clinical signs. However, whenever dogs with clinical elbow dysplasia are diagnosed, it is usually found that several closely related dogs have Grade I elbow dysplasia on radiographs. When owners send in radiographs to OFA for hip dysplasia rating, they should also send in elbow radiographs. It only costs $5 more for the evaluation, but can prevent surprises latter on.

Of female reproductive problems, pyometra is the most frequent listed problem, followed by problems with whelping. These are the most frequent female reproductive problems in all breeds, and are probably not a greater problem in the Samoyed. What places this category so high in the survey is a large portion of respondents checking off "other" female reproductive problems.

There are no specific forms of cancer that are reported at a high frequency in the health survey. The incidence of cancers have to be evaluated compared to ages of onset, to see if any appear at earlier ages than expected in older dogs.

Among ophthalmic (eye) disorders, cataracts account for 17% of those responding. Six percent of dogs with eye problems had progressive retinal atrophy (PRA), and 2% had other retinal disease. According to the Canine Eye Registry Foundation (CERF), which summarizes eye examinations by all American veterinary ophthalmologists, 10.33% of all Samoyeds have cataracts. This is followed by misplaced eyelashes that can injure the cornea (distichiasis) 6.71%, corneal dystrophy 4.15%, retinal dysplasia 4.05%, persistent pupillary membranes 1.84%, other inherited disorders 1.32%, PRA 0.61%, and glaucoma 0.17%.

The following is specific information on ocular disorders reported in the breed: Juvenile (posterior cortical) cataracts occur in the Samoyed with an average age of onset of 6 months to 2 years of age. An AKC Canine Health Foundation funded research project is underway to identify a defective gene, or a molecular genetic marker for the disorder, to be used as a screening test. If you own a dog that is affected, or closely related to a Samoyed with juvenile cataracts, please contact Dr. Vilma Yuzbasiyan-Gurkan at the Michigan State University School of Veterinary Medicine (517-432-0144). You will be asked to provide DNA for the research through a cheek swab sample. The identity of dogs submitting samples is confidential.

There is a form of retinal dysplasia occurring in the breed that is incompletely dominant. When a Samoyed carries two of these dominant genes, it will be both blind, and a short-limbed dwarf with bowing of the wrists. X-linked PRA affects mostly male dogs, as they only need one gene to be affected. Females require defective genes on both their X-chromosomes to be affected. Blindness is usually apparent between 4 to 5 years of age. Uveodermatologic (VKH-like) syndrome is an immune mediated disease with uveitis (severe ocular inflammation) that can lead to blindness, and whitening (depigmentation) of the skin and hair. Onset is usually 1 to 4-1/2 years of age. The mode of inheritance has not been determined.

Of endocrine disorders reported in the Samoyed, hypothyroidism is the most frequent. Hereditary hypothyroidism is an immune-mediated disease, with autoantibodies being produced that are destructive to the thyroid gland. Measurable autoantibodies are only present during the period of thyroid destruction

(usually sometime between 2-6 years of age). Annual testing for thyroglobulin autoantibodies should be done between these years. After the thyroid gland is destroyed, and the dog has low measurable thyroid hormone levels, there is usually no more measurable autoantibodies present. This is often misdiagnosed as idiopathic hypothyroidism, but in most instances is the end stage of hereditary autoimmune thyroiditis. This is why it is important to screen your dogs for measurable thyroid autoantibodies during the critical period to be able to properly diagnose the disorder, and utilize this tool in genetic disease control. The mode of inheritance of hereditary hypothyroidism has not been determined.

Michigan State University (one frequently used endocrine testing facility) reports 7.4% of 299 Samoyeds with measurable autoantibodies to their thyroid gland. The average for all breeds is 7.9%. While the level in Samoyed is slightly less than the average of all breeds, owners should test their breeding stock to prevent it's spread in the population.

Statistical research shows that Samoyed are 12 times more susceptible to develop diabetes mellitus (sugar diabetes) than other dogs. The average onset is 7 years of age, with a range of 4 to 10 years of age. Affected dogs can be controlled with insulin regulation. Dr. Rebecka Hess, at the University of Pennsylvania School of Veterinary Medicine is researching the disorder in the breed. If you have an affected dog, or one closely related to an affected dog, please contact her at (215) 898-9427.

Of gastrointestinal problems, gastric dilation (bloat), with or without volvulus, is the most frequent problem. Not much is known about the genetic factors involved with bloat. It is recognized that large, barrel-chested breeds are the most prone to the disorder. Dr. Larry Glickman, at Purdue University School of Veterinary Medicine, conducted an AKC Canine Health Foundation funded study on bloat. He found that an increased chest depth/width ratio, fast eaters, and dogs with primary relatives that bloated have the highest risk of bloating themselves. The risk also increases, as the dog gets older. A controversial factor Dr. Glickman identified was that using a raised food bowl was correlated to an increased risk of developing bloat. Irritable bowel syndrome also occurs in the breed.

Hereditary nephritis was reported in the breed in 1987 as an X-linked dominant disorder. Affected males start with clinical signs around 3 months of age, and die of renal failure between 1 and 2 years of age. Females are less severely affected, but can develop renal failure later in life. The original study included members from one family of Samoyed, and it is possible that this disorder no longer exists in the population.

Of temperament problems, aggression is the most frequent, representing 86% of Samoyeds reported with behavior problems. The remaining 14% represented dogs with overt shyness. Breeders should recognize that temperament problems have a strong genetic component.

Other disorders reported in the Samoyed include diabetes insipidus (non-sugar diabetes), sebaceous adenitis (a skin condition causing symmetrical hairloss), pulmonic stenosis and atrial septal defect (two congenital heart anomalies that can cause heart failure), infantile tremor syndrome (contact Dr. Ian Duncan at the University of Wisconsin (608-265-1129)), and porto-systemic shunts (blood vessels that bypass the liver, causing stunted growth, abnormal behavior, and seizures).

The fact that we are listing all of these breed-related disorders does not mean that the breed is riddled with problems. These are just the problems that breeders should be vigilant about, and screen for in their breeding and pet dogs.

Managing Genetic Disorders

Along with the new tools of genetic tests, there is a new philosophy for managing genetic disorders. Recognizing that breeders own dogs that they favor; recommendations to eliminate their dogs from breeding and use other dogs is counterproductive. There are breeding recommendations that both preserve breeding lines, and manage genetic disorders.

Management recommendations for genetic disorders will vary due to many factors. These include the mode of inheritance, the availability of genetic tests, the size of the breed gene pool and it's diversity, and

the spread of the defective gene(s) causing the disorder. With disorders caused by simple dominant genes, everyone with the gene is affected, so these should be easier to manage. You want to replace affected dogs in your breeding program with normal siblings, the normal parent, or prior born offspring. Ideally you do not want to breed affected dogs and produce more affected individuals. If the disorder shows incomplete penetrance, where a dog may have the gene, but not the disorder, selection is more difficult. You should follow the recommendations for recessive genes without tests for carriers.

Managing simple recessive disorders is straightforward if there is a test for carriers: Breed carriers to genetically normal mates, and replace the carrier parent with a genetically normal offspring that equals or surpasses it in quality. For a testable disorder, with a quality dog you are planning on breeding, a carrier test result should not alter your breeding decision. The worse thing breeders can do is to not breed quality dogs due to a single testable defective gene that can be eliminated in one generation. With tens of thousands of genes present in each dog, such a practice will narrow the genetic diversity of the breed gene pool, possibly increasing the frequency of other deleterious genes in the population. As additional genetic tests are developed, the chance of identifying a deleterious gene in all dogs increases. On the other hand, with quality carrier offspring, you do not want to breed more carrier offspring than the carrier parent that you are eliminating, as this will act to increase the frequency of the gene in the breeding population.

A problem with recessive genes and disorders is the spread of unapparent carriers. On average, two-thirds of clinically normal sibs of affected dogs will be carriers, half of the sibs of the parents of affected dogs will be carriers, two grandparents of affected dogs, plus half of their sibs will be carriers, etc. The only matings that produce dogs affected with a simple autosomal recessive disorder are those where both parents are either carriers or affected. Unfortunately, the vast majority of matings involving a carrier are those bred to genetically normal mates. These matings will not produce affected dogs, but will multiply and propagate the defective gene in carrier offspring.

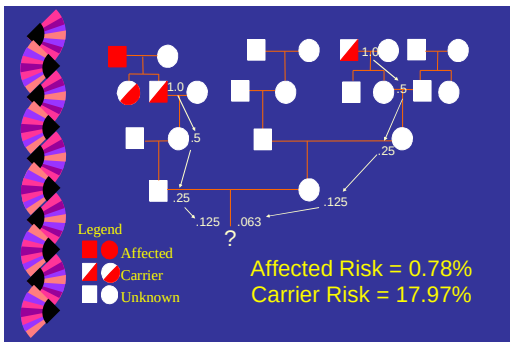
To combat the spread of genetic disorders, many researchers are working to identify the defective genes that cause them. There are two methods of identifying defective genes. The candidate gene approach looks at genes that have been identified to be involved in the affected body system in dogs or even other species. If an abnormality is found in both copies of the candidate gene in all recessively affected dogs, one is abnormal in all known carriers, and all genetically normal dogs have two normal copies of the gene, then the candidate gene is the cause of the disorder. With this knowledge, a direct gene test can be made that can unequivocally identify affected, carrier, and genetically normal dogs.

If there are no candidate genes, or none prove to be involved in the genetic disorder, then a linkage analysis approach may be fruitful. There are genetic markers spread across all of the chromosomes of the dog. If a marker is found to be present twice in affected dogs, once in carrier dogs, and none in normal dogs, then the marker may be linked to the defective gene. With a linked marker, the defective gene has not been identified, but a marker that lies close to it on the chromosome has. With a linkage-based test, there can be false positive and false negative test results, depending on whether a chromosome crossover between the marker and the defective gene has occurred. If this occurs, then the linkage test will not be able to accurately test for the defective gene in the dog's descendents.

Understanding the types of genetic tests that are available will allow breeders to use them properly. Are there tests available that identify the dog's genotype (affected, carrier, normal), or just it's phenotype (affected or not affected)? What is the minimum age necessary for an accurate test of the phenotype (such as hip radiographs, eye examinations, thyroid autoantibodies, etc.)? For linkage-based tests, what is the predicted frequency of false results?

If there is a direct gene test, then you as a breeder only have to know the results of your breeding dog, and that of the proposed mates. For a phenotypic test, linkage test, or if there is no test for carriers, then knowledge of the test results or carrier or affected status of relatives is important. Especially important is full-sibling information for prospective mates and their parents.

Without tests for carriers of recessive disorders, relative risk pedigree analysis can be used to compute risk factors for producing carrier and affected offspring. If a researcher determines the average risk of being a carrier of a specific defective gene for the breed, then breeders should attempt matings with risk factors below this average. Breeders can compare the carrier risk of prospective mates, and factor this into their breeding decisions.

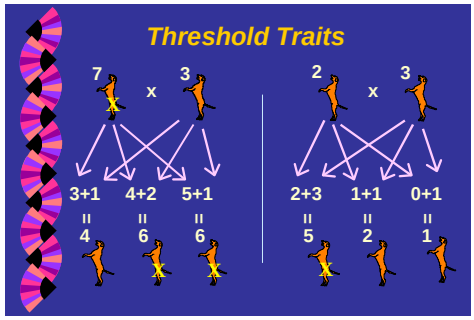


Relative risk analysis requires openness between both breeders and owners about confirmed affected and carrier dogs, and works best with an open health registry. It allows breeders with higher risk breeding dogs to lower their risk, and provides an objective comparison of dogs. The downside of this analysis is that it applies risk to whole families, and not to just the individuals who may be a carrier. Therefore, it's use selects against carrier and normal dogs. However, without a test for carriers, it is the only objective tool available to assist breeders with high carrier-risk dogs.

The Canine Health Information Center (CHIC) has been established by the AKC Canine Health Foundation, and the Orthopedic Foundation for Animals. Each parent breed club will determine the testable disorders for the breed, in an open, or semi-open on-line registry. The beauty of the CHIC program is that for a dog to get CHIC certification, it only has to complete all the required genetic tests - not pass all of them. CHIC certification is a statement of health consciousness, not perfection. Breeders can search online for the test results of prospective mates that are compatible with their own dogs.

Hip Dysplasia as an example of a Polygenic Disorder

Polygenic disorders are more difficult to manage than simple one-gene disorders. For selective pressure against polygenic disorders, they have to be considered as threshold traits. A number of liability genes must combine together to cross a threshold causing the disorder to be expressed. If we consider a theoretical situation where five genes must combine to cross a threshold to produce a dog with hip dysplasia, a mating between a dysplastic dog with 7 dysplasia liability genes, and a normal dog with three genes would be expected to produce a higher than average rate of dysplastic offspring. If two normal dogs produce an affected dog with a polygenic disorder, then BOTH parents must have contributed liability genes to the mating.



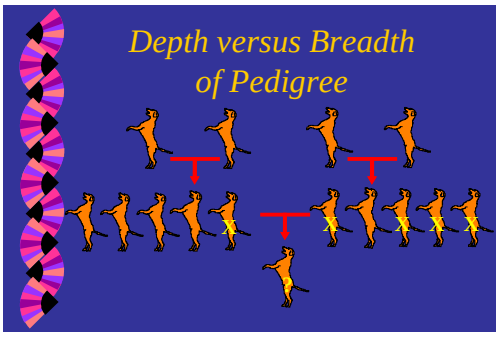
Breeders need to break down what you see in the phenotype into traits that may be more closely related to individual genes. For canine hip dysplasia, the pelvic radiograph can tell you much about why a dog received a fair versus good rating, or why it was rated as dysplastic. If the problem is mild laxity, in an otherwise superior dog, breeding to a dog with tight hips may provide a better response. If the problem is a shallow acetabulum, then breeding to a dog with deep hip sockets may provide the genes necessary for better hip conformation.

Some breeders and owners ask about the difference between OFA certification (the ventrodorsal pelvic radiograph) and PennHip certification (hip distracted radiograph). The OFA provides information on the anatomy of the hip joint, bony arthritic changes, as well as passive laxity in the hip extended view. The PennHip method isolates and provides an objective measurement of laxity as a major factor for the development of hip dysplasia. Both methods have similar low levels of false positive and false negative results. While PennHip will certify at an early age, and OFA will only provide preliminary certification before two years of age, both have similar accuracy in each age group in predicting later hip dysplasia. The OFA method provides a grading and allows the owner to evaluate all aspects of the hip conformation. If there is a problem with hip joint laxity, the PennHip method will allow breeders to select for tighter hips through their selective breeding.

There is no OFA excellent gene that breeders can select for. Different dogs have fair, good, excellent, or dysplastic hips due to different genetic reasons. By evaluating a pelvic radiograph with your veterinarian and selecting for the components of the hip that need improvement, you increase the likelihood of improvement in your matings. You should also consider whether there are any clinical signs of hip pain (either presently, or during the growth period of six to eighteen months), and palpable hip laxity under anesthesia to fully evaluate the hip status of a dog.

Environmental factors can affect the expression of polygenic disorders, and this is also true with hip dysplasia. We know that rapid weight gain at an early age can produce "sloppy" hips; where the maturation of the ligament and muscle components does not keep up with bone growth. By switching from puppy food to adult food after 14 weeks of age, or using large breed puppy food, dogs grow at a slower, and more uniform rate. The adult size and stature of a dog is genetically predetermined. How fast a dog reaches its adult size can influence the expression of hip dysplasia.

The most important factor in selecting against polygenic disorders is utilizing the breadth of the pedigree. Most breeders select for depth of pedigree; normal breeding dogs with normal parents. The status of the littermates of the prospective breeding dogs, and littermates of their parents provides the most information on the possible range of genes carried. A normal dog from normal, or mostly normal litters, provides the best evidence of a low genetic load for disease susceptibility genes. Normal dogs with affected littermates probably have a higher genetic load for the disorder.



A "vertical mating" system is a method to control polygenic disorders, recessive disorders without a test for carriers, or disorders without a known mode of inheritance. A dog of quality with high carrier risk should be bred to a dog with lower carrier risk, resulting in a carrier risk in the offspring lower than the average of the breed. Replace the higher-risk parent with a quality, lower-risk offspring. Repeat the process in the next generation. The number of breeding offspring should be limited from such matings. By breeding once and replacing, you are not propagating and disseminating defective genes into the population. Store semen and DNA from quality stud dogs for future use when a genetic test may become available. Even if the dog turns out to be a carrier, his semen can be used on a normal bitch, and the line carried on with genetically normal offspring. A vertical mating scheme retains the good genes of a line, reduces the carrier risk with each generation, and does not add to the overall carrier risk in the population.

As stated earlier, the Samoyed breed is diverse, and relatively healthy compared with other breeds. Samoyed breeders should concentrate on maintaining and enhancing the quality of the breed, and avoid the popular sire syndrome. Breeders should use genetic tests to identify carriers or high-risk dogs, work to breed away from defective genes, and prevent the reintroduction of the genes in future breedings. Each breeder must assess their own breeding stock, and determine their own rate of progress. A healthy breeding program does not continually multiply carriers, does not limit the genetic diversity of the gene pool, and is geared toward producing quality, genetically normal dogs.