The AKC DNA Program: Past and Present

By Mark Dunn
Executive Vice President, American Kennel Club

History and Technology Choices

For more than twenty years the American Kennel Club has harnessed the power of genotyping technology to ensure the integrity of its registry and to assist breeders with the accuracy of their breeding records by determining whether a recorded sire or dam could be genetically excluded from the parentage of its recorded progeny.

In the late 1990's, AKC began using a panel of 10 Short Tandem Repeat (STR) markers for parentage evaluations. In 2003, AKC moved to the SuperPlex-G panel, comprised of 13 STR markers plus a gender marker. The SuperPlex-G panel is still in use today and provides a dog's AKC DNA profile for identification and parentage; it does not provide any information about the conformation, breed, or the presence/absence of genetic diseases. Comparison of the SuperPlex-G profiles of a dam, a sire and their progeny will determine, with greater than 99% confidence, whether the progeny are from the tested dam and sire. Each new AKC DNA profile is systematically compared to the genotypes of all previously profiled AKC registered dogs and litters whelped on or after January 1, 2000.

As of August 2020, the SuperPlex-G STR panel was still providing the majority of AKC's genotyping needs. However, newer technologies, leveraging use of genome-wide genetic variance, offer improved cost efficiencies, sample throughput, and processing options, as well as the ability to easily and inexpensively collect additional markers to support canine research and/or offer future services to AKC breeders.

To explore potential changes in technology, the AKC co-authored with scientists from UC Davis, Cornell, Geneseek, Genoscoper and Mars Veterinary a study presented at the 2016 International Society for Animal Genetics Conference. The objectives of the study were:

1) to evaluate minor allele frequencies (MAF) of a few hundred selected canine single nucleotide polymorphisms (SNPs) for popular dog breeds

2) to design multiplex SNP panels using a subset of these SNPs for evaluating their effectiveness in parentage analysis using well-defined trios, and

3) to determine the concordance of parentage results obtained by both STR and SNP independently

The study proved that SNPs can be effectively multiplexed in a manner allowing equal or better determination of canine parentage compared to traditional STR markers.

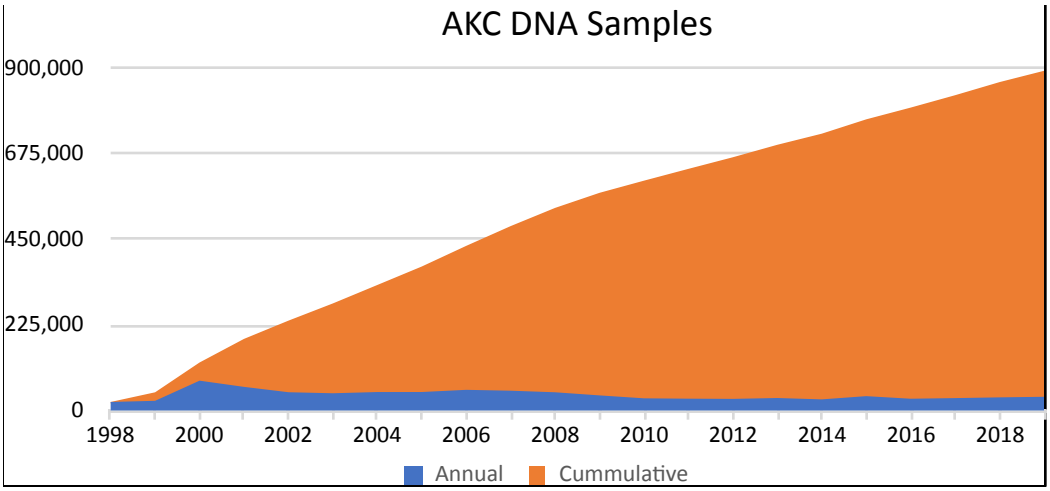
In 2019, AKC supported a research study at North Carolina State University (Drs. Breen and Allwood) to evaluate cross platform genotyping and finalize the SNPs best suited for AKC parentage purposes. Importantly, this study used canines previously genotyped using the current standard SuperPlex-G STR panel. The study demonstrated concordance of parentage data across multiple vendors when comparing STRs with SNP by GBS (genotyping-by-sequencing) data and led to the development of a new proprietary SNP panel for AKC use.

Current AKC DNA Programs and Products

The AKC has a comprehensive set of voluntary and mandatory programs used to ensure the integrity of the AKC registry and assist breeders with the accuracy of their breeding records, including:

- Voluntary DNA Profile Program
- Kennel Inspections/Compliance Audit Program (CAP)
- Frequently Used Sires Requirement (FUS)
- Fresh-Extended/Frozen Semen Requirement
- Multiple-Sired Litter Registration Policy
- AKC Parentage Evaluation Program
- Imported Breeding Stock Requirement
- Conditional Registration

Through these programs and products, AKC has built one of the world's largest databases of canine DNA profiles for parentage verification and genetic identity purposes, with nearly 900,000 profiles.



Voluntary DNA Profile Program: The AKC DNA program allows owners and breeders to eliminate concerns or questions about identification and parentage. A dog owner may order an AKC DNA Test Kit via AKC.org or by phone. The kit includes a swab that the owner uses to collect loose cells from inside the dog's cheek. An AKC DNA Profile containing the dog's registration information, genotype, and a unique DNA Profile number is issued for each dog sampled. This DNA Profile number will appear on subsequently issued AKC Registration Certificates and Pedigrees. Many breeders opt to voluntarily submit for DNA profiling in advance or anticipation of AKC mandatory requirements such as **FUS**.

Kennel Inspections/Compliance Audit Program (CAP): DNA samples are sometimes collected by AKC Field Inspectors who perform approximately 3,000 kennel inspections each year. The collection of such samples is at the discretion of the inspector and is usually only conducted when the inspector has concerns regarding the breeder's ability to properly identify dogs in their care. Typically, the inspector will collect DNA samples from a litter of puppies as well as the dam and sire indicated by the breeder to be the parents of the puppies. Breeders are not charged for the cost of processing the samples but must account for any discrepancies identified by the analysis. AKC DNA Operations staff will work closely with breeders to resolve parentage exclusions and most initial exclusions cases are resolved, but, if unsuccessful, some or all the puppies sampled may be conditionalized (see **AKC Conditional Registration**). Breeders with record-keeping errors face a graduated scale of discipline including fines and suspensions.

Frequently Used Sires Requirement (FUS): In January 2000, the AKC Board of Directors approved the policy now known as **Frequently Used Sires Requirement (FUS)**. This AKC Board Policy requires the mandatory genotyping at the breeder's expense of all sires prior to the registration of a 4th litter in any calendar year or a 7th litter in a sire's lifetime. This program ensures that AKC has DNA profiles for those dogs with the greatest impact on the AKC Stud Book. Approximately 67% of the DNA samples submitted to AKC are for dogs that meet or will

eventually meet the mandatory **FUS** requirements. Breeders who purchase breeding stock or stud duty from other breeders can find the veracity of their own breeding programs called into question if the purchased sire/stud is later determined to be excluded from its own documented parents. Therefore, breeders are encouraged to use AKC's voluntary DNA program to verify parentage of purchased breeding stock prior to any breeding. As with **CAP**, AKC DNA Operations staff will work closely with breeders to resolve parentage exclusions, but, when unsuccessful, some or all the puppies sampled may be conditionalized (see **AKC Conditional Registration**). Unlike **CAP**, such discrepancies rarely result in fines or other disciplinary action.

Fresh-Extended/Frozen Semen Requirement: Since October 1998, the AKC has required the mandatory genotyping, at the breeder's expense, of all stud dogs whose semen is collected for frozen or fresh extended use. DNA profiling is not required for artificial inseminations wherein both dog and bitch are present.

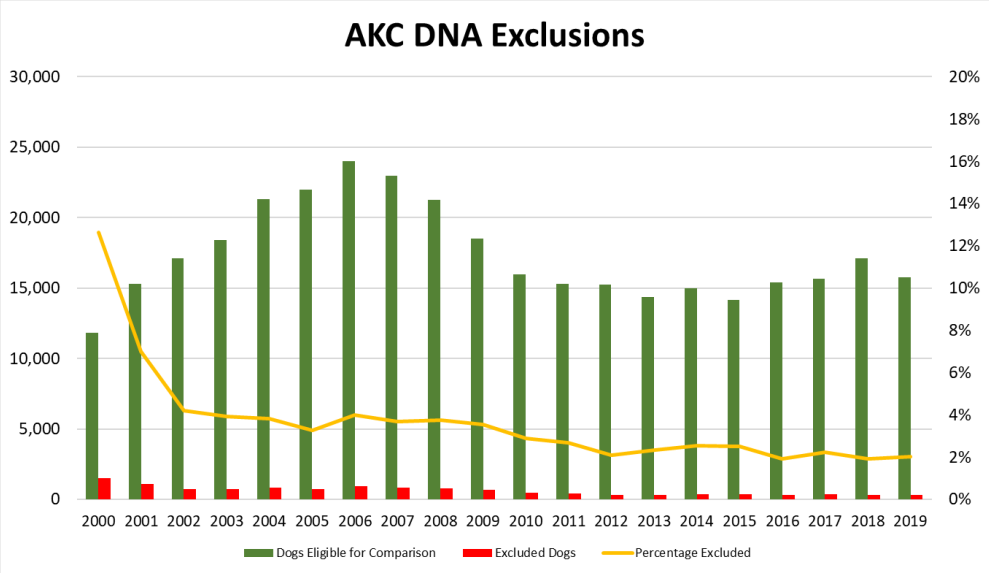
Multiple-Sired Litter Registration Policy: Since September 1998, AKC has required the mandatory genotyping, at the breeder's expense, of all potential sires as well as the dam and all puppies of any multi-sired litter. Breeders may use the genotyping results to make their own determination of parentage or they may request AKC to provide this service for an additional fee (see **AKC Parentage Evaluation Program**).

AKC Parentage Evaluation Program: The AKC will evaluate the parentage of a litter and provide a Parentage Evaluation Table and written report based upon genotypes on file with the AKC. Breeders will need to submit DNA samples for any canines not already present in AKC's DNA database at the time of the request for **AKC Parentage Evaluation**. This service prevents registration application errors by identifying the likely sire(s) for breeders with multi-sired litters or those with possible multi-sired litters. The canines sampled do not need to be AKC registered to participate in the evaluation.

Imported Breeding Stock Requirement: Imported dogs registered on or after March 1, 2006, must have an AKC DNA profile prior to registering an AKC litter whelped in the United States. This requirement applies to both males and females.

Exclusions: The AKC developed its DNA program and requirements to ensure the integrity of its registry and assist breeders with the accuracy of their records. The earliest broad implementation of DNA profiling by AKC was, as mentioned above, the **AKC Compliance Audit Program (CAP)** which in 1998 returned an exclusion rate of 10%, meaning only 90% of the DNA profiled litters were correct. It should be noted that the **CAP** sampling methodology has a bias towards exclusions, as the CAP sample collections are performed by the AKC Inspectors, often when errors are suspected. Nonetheless, the AKC took notice of this exclusion rate and over the next decade developed the full suite of requirements and products outlined herein.

With the current DNA database containing nearly 900,000 profiles collected over the past two decades, the AKC can evaluate the integrity of the registry with more precision than in 1998. Each year the AKC receives almost 40,000 DNA samples, and, when available, each resulting profile is compared to its parents and/or its progeny. In 2000, the AKC's average rate of exclusion was 12.6%. Through education and compliance, the AKC was able to reduce the exclusion rate to less than 3% by 2010, and it is now approximately 2%.



AKC Conditional Registration

Until 2006, unresolved parentage exclusions resulted in the cancellation of the excluded dog and its progeny. In 2005, the AKC Board of Directors approved a measure whereby excluded dogs and their progeny are issued AKC Conditional Registration Certificates and Pedigrees instead of being cancelled. This conditionalization process is used only when the excluded dogs are believed to be purebred. "Unknown" will be noted on the registration or pedigree for the ancestor in question and any male/female bred to a dog with **AKC Conditional Registration** is required to have DNA on file with AKC in order to register a litter. The downgrade to conditional status will remain in effect for the excluded dog(s) and all progeny until a three-generation pedigree of AKC DNA verified parentage is established. The documents issued to conditionalized dogs are clearly labeled as Conditional. AKC Conditional Registration allows breeders to work though parentage issues without totally removing purebred dogs from the gene pool. By fully documenting and disclosing the incident of unknown parentage, breeders and dog owners can make their own informed decisions about whether they will buy or breed a certain dog.

<u>Summary</u>

The AKC DNA Program is one of the oldest continuously operating canine DNA operations in the world. With nearly 900,000 canines profiled, more than 500,000 canine DNA samples in storage, and more than 250,000 participating breeders, the AKC remains a leader and innovator in this important field. Now in its third decade, the program is well positioned to take advantage of new and emerging technologies to assist breeders and dog owners alike.