A PRACTICAL GUIDE FOR VETERINARIANS, VETERINARY STAFF, AND BREEDERS

CANINE

Reproduction and Neonatology

Marthina L. Greer, DVM, JD

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TETON NEWMEDIA
INNOVATIVE PUBLISHING OF VETERINARY & HUMAN MEDICINE

Teton NewMedia
Teton NewMedia
90 East Simpson, Suite 110
Jackson, WY 83001

Exclusive worldwide distribution by CRC Press an imprint of Taylor & Francis Group, an Informa business
Version Date: 20141126

International Standard Book Number-13: 978-1-4987-2850-8 (eBook - PDF)

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Preface

Breeder clients cannot be stereotyped and classified any more than the rest of your client base. The majority of our breeder clients are seeking a high level of care, both for fertility work and for emergency care. This is the client base for which this book is written.

In today's medical climate of "evidence-based medicine", there are still fields in veterinary care that cannot rely on this process. Although there are protocols where published and researched information can be applied, many decisions in the scope of the topics in this book are based on common sense, intuition and experience.

Many breeder clients are very well-informed and have a great deal of experience. They are often demanding and frequently require after-hours care for timed breedings, whelpings, as well as pediatric and prenatal care. We look at working with these clients as a joy and a challenge. We hope you find this book to be valuable when you need a readily retrievable, practical resource.

For the veterinarian without a great deal of experience in breeding and whelping dogs, working with breeders can be a great learning experience. For veterinarians with more experience, we find the most effective way to work with these clients is to listen carefully to their opinions, guide them to a compromise with the science on your side, and never doubt their gut instincts.

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Dedication

I would like to dedicate this book to my family, staff, and clients.

To my parents, Dave and Nancy Greer, who taught me I could do anything in life I wanted to. And for putting me up and putting up with me during the warm Phoenix winters so I could get away from practice and school to concentrate on writing.

To my husband, Dan Griffiths and kids Katy and Karl, for picking up the slack.

To my fabulous staff, for always being there when we needed them. To Trish and Dr. Zella for pushing me hard enough to make this happen.

To my terrific clients, who taught me all you see represented in this book. To Ch. Jane Marple and her grand-dogs who taught me humility and boundaries.

To Carroll Cann, for his patience.

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CHAPTER 1
Working with Breeders

What is "Normal" reproduction?

As we have always been taught, you must know "normal" to know "abnormal". So how do we define "normal"?

As veterinarians, we seldom experience "normal" reproduction. This is because many breeders are very skilled in handling breeding timing, the actual breeding, the pregnancy and the whelping and require little veterinary intervention. However, according to current AKC records, 60% of all breedings are now handled by some form of artificial insemination and veterinarians are more likely to be involved. We will have more and more to offer these technically skilled clients as more sophisticated techniques become available, which now include shipping fresh and frozen semen necessitating veterinary assistance in insemination, and as clients come to expect more advanced care.

Veterinarians may think of "normal" as the breeder who owns both the stud dog and bitch or uses a stud dog near her home. In this scenario, the breeder makes his or her own arrangements for breeding including the timing based on behavior of the stud dog and bitch. They handle the breeding either by natural breeding by copulation or doing an artificial insemination themselves. They either assume their breeding has been successful or diagnose the pregnancy themselves based on palpation. They manage the bitch throughout her pregnancy. The whelping takes place uneventfully at their home or kennel and the breeder assesses that the bitch has completed whelping based on their own palpation or on another assumption. They handle the puppies through their neonatal period. All either goes off without a hitch or the breeder is willing to accept the situation and does not ask for veterinary intervention. Many breeders will seek out more advanced veterinary services if we are available to provide them.

Who are the breeders?

There are many different varieties of breeders, just as there are many different types of pet-owning clients. They can be categorized, but this is done at the risk of failing to recognize overlap between categories and of stereotyping. Nevertheless, it is helpful to know that there are differences.

Breeders involved in competitive events

These are breeders who are in some form of competition and thus breed with specific guidelines of the "perfect dog" in mind when selecting breeding stock. This may include dogs who compete in conformation (appearance, based on a breed standard), agility, flyball, tracking, herding, coursing, field and hunting dogs, earth dogs, bear and raccoon hunting, to name some representative categories. They tend to travel long distances to attend these events and may have professional trainers or hire handlers for competitive events.

These dogs are bred for a specific performance purpose following pedigree analysis by the breeder and they have been screened for genetic diseases.

Most of these breeders have several dogs, 2 to 20, of the same or related breeds (usually 1 or 2 breeds) and have devoted themselves to either maintaining or improving their breed for many years, sometimes a lifetime. These dogs tend to live in the home of the breeder or in a small well-maintained kennel built to the breeder's specifications.

Many breeders will produce one to several litters a year. They sell directly to the end consumer, your dog-owning client. They will have interviews with prospective puppy buyers and have a waiting list of potential homes. They rarely run ads to sell pups. These breeders are likely to keep one or more puppies from each litter to continue their performance involvement and breeding with young stock. The breeder will often keep the puppies until at least 8 weeks of age for socialization and determination of the pup they want to keep. Placement is based on which puppy is best suited

for which family. In some cases, they may "run on several puppies", in other words, keep several littermates until they are adolescent when they are better able to tell which puppy they want to keep for performance and breeding.

To keep their numbers manageable, some breeders will place breeding age dogs in family homes and have them return briefly for breeding. Some prefer to place adult dogs in single dog homes after they are finished competing, breeding, and spaying or neutering.

This type of breeder is frequently a member of one or more dog breed clubs. They may belong to a local kennel club and also one or more breed specific clubs with restricted memberships. They often participate in breed specific "rescue", where if a dog of their breed is relinquished to a humane society or shelter, they will actively attempt to provide a foster home until they can re-home the dog.

Many of these breeders will sell dogs with health guarantees and on some type of contract with the buyer. Often, the contract will state that the pup is to be returned to the breeder if the family who has made the purchase cannot keep the dog – this minimizes the likelihood that their pups will end up in shelters and in rescue organizations. Many will sell the puppies with a "limited" AKC registration, meaning if these pups are used for breeding, their offspring cannot be registered with AKC. These pups are usually sold after being evaluated by a veterinarian. Some pups are wormed and vaccinated by the breeder and some by the attending veterinarian, but they tend to have supporting veterinary paperwork and a well-thought out vaccine and worming schedule.

Pet breeders

These breeders tend to breed for the pet dog market, but not for competition. They often own one or two dogs of their specific breed. These tend to live in the home or in a small kennel in the garage.

Some have a litter to expose their children to the wonders of birth. Many have only one or two litters total. Others breed their dogs because they purchased it as a puppy and want to "make some of the money back" that they spent on the purchase. Some breed because they have friends, family and co-workers who said they want one "just like her". Some breed to try to recreate the dog they have now.

Pet breeders are less likely to do health screening tests and research pedigrees when choosing a mate for the dog. They will often purchase a second dog of the opposite sex for breeding to their first dog. They frequently keep one of the pups as a replacement for the older dog. Some intentionally breed two different breeds together.

Commercial breeders

"Puppy mills" is a common but not necessarily accurate term used for commercial breeders. They tend to raise many puppies (in the double to quadruple digits), many different breeds (over five), and often raise mixed breed dogs (designer dogs – which changes with the public's preferences). They may have signs posted where they can change the listing of the breeds available and may run newspaper and internet ads listing all of the breeds available or run multiple ads by breed.

Some commercial breeders house the dogs in groups, in barns or other buildings converted for this purpose. As a result, the parentage may be difficult to ascertain. Some commercial breeders have facilities far superior to that of breeders who are involved in competitive events. If they sell directly to the consumer, the buyer, may not be invited to the premises (the breeder may meet the buyer off site – "we live way out in the country and it is so hard to find us") or you may not be allowed to see the dogs and the dog's parents where they are housed. Some sell directly to the public through another breeder-friend as a broker, but this is the only group of breeders who sell puppies through pet stores. Buyers often find them on the internet.

Commercial breeders often have USDA and/or state certification and are routinely inspected by USDA, the state, and/or AKC. The paperwork that accompanies the puppies may include USDA health papers since the puppies frequently cross state lines. There may not be any other veterinary records. Puppies are often sold and transported under 7 weeks of age. Vaccines tend to be given from a very early age (under 6 weeks), given frequently, and administered by the breeder. The vaccines used may be brands you do not use in your practice; worming protocols include drugs such as Ivermectin® and coccidiostats from a very early age (2 weeks) on. The pups often originate from Midwestern states in the U.S. or from outside the U.S. (Mexico and islands off the coast of the U.S.)

The buyers (who are your well-meaning clients) are often convinced that they are not buying from a commercial breeder, or make the purchase out of pity for the puppy. The commercial breeder will rarely sell the pups on a limited registration or with a contract with the buyer.

Why work with breeders?

The breeder client of all types can be a boon to your client base. Not only will they build your practice by being clients, but also by referring fellow dog-breeders and new puppy buyers to you. Some veterinarians begin to work with breeders when they are breeders themselves.

How to work with breeders

The "Competition breeder client"

The competitive breeder client is usually well-educated, challenging, and demanding. They know their lines of dogs, are well connected in the breed, and have many resources. They are very aware of the genetic screening tests available, often outpacing the veterinarian as this field is changing very rapidly. They have been breeding dogs for many years and usually have with great skills in breeding, whelping, and neonatal care.

The inexperienced veterinarian may find this group intimidating at first exposure. Unfortunately, the "breeder client" is not always well received in many veterinary clinics in the U.S. Veterinarians who seek to assist breeders find that when handled correctly, these clients are hungry to learn more, appreciate the services available, and can teach us as much as we teach them. Although the breeder may initiate the veterinary visit with a seemingly strong opinion, when countered with respect and a well-thought out scientific approach to the situation, they will frequently be convinced to treat as the veterinarian proposes or a medically appropriate compromise may be made.

If the veterinarian is willing to offer breeding services and develop a mutual exchange of information with the breeder client, a truly wonderful working relationship can evolve.

The breeder client will sometimes request a "breeder" discount. This may or may not be appropriate and each veterinary hospital must have its own policy. The hospital may choose to discount some, but not all services. For instance, you may discount vaccinations, but not reproductive services only sought out by breeders. The breeder client often brings in multiple puppies or adult dogs at one visit, making more efficient use of the veterinarian's time. They can also serve as a wonderful source of referrals when their puppies are placed in homes in your community. For a practice seeking a source of new clients, this can work out very well.

Additionally, the opportunity to aid breeders can be immensely rewarding. There are few procedures that bring greater joy in veterinary practice than a cooperative effort with a client that results in the birth of a healthy litter of puppies that you had a hand in producing.

The "Pet puppy breeder"

These clients can be less challenging regarding the services requested and the hours that they

expect you to be available. They ask less difficult questions and do not generally go to the same extremes as the competition breeder. They usually use a local dog and ask for less intervention on timing, prenatal care, and other services. They appreciate the assistance.

The "Commercial breeder"

These clients often use the veterinarian for USDA certificates and "herd management" issues but not individual pet care. These pets are at the greatest risk of diseases such as parasites and brucellosis as they move in and out of their kennels and those of others who transact business in the same way often overlooking the importance of testing and quarantining to prevent diseases.

What skills does a veterinarian need to develop to provide basic reproductive care?

1. Semen collection including sperm counts, motility, and morphology.
2. Artificial insemination – vaginal and surgical insemination.
3. Ovulation timing and breeding management.
4. Pregnancy diagnosis with ultrasound and radiographs, including estimations of litter size and due dates.
5. C-sections – surgical technique, dystocia management, and puppy resuscitation.
6. Prenatal and postpartum management of the bitch.
7. Neonatal and pediatric care.
8. Infertility evaluation and treatment for males and females.
9. Treatment options for pyometras, uterine disease, prostate disease, accidental breedings, and mammary disease.
10. Good client education tools, including handouts.

Caseload – Emergency care, weekends

Breedings and whelpings happen 365 days a year, holiday or weekend. Babies come when they are ready and bitches need to be bred when they have ovulated. If you choose to work with breeders and are willing to make yourself available to them on weekends, nights, and holidays, they will deeply appreciate your efforts. Of course, you should charge appropriately for these services and explain this to them if necessary.

As valuable as emergency clinic services are, they are usually not suited to assisting the breeder client with semen collection for shipment and weekend artificial breedings. They are often very busy with critically ill and injured patients and are neither staffed nor equipped to provide breeding services.

C-sections can frequently be handled very well by general practitioners, but in some situations are better handled at emergency and referral practices.

If the general practitioner has the veterinary and support staff and equipment to perform a successful C-section, this can be a wonderful service to offer to your breeder clients. Of course, this requires that you make proceeding to surgery a priority in the practice, whether during a routine day or after hours.

If the practice does not have sufficient staff to have a ratio of one support staff for every two anticipated puppies or does not have anesthesia and equipment for C-sections and the associated complications, it may be best to refer to an emergency clinic.

Whether in general, referral or emergency practice, we must remember our caesarian patient is not one patient but a group of patients. When faced with a bitch with a dystocia or premature labor, we must keep in mind that a delay in assessment and treatment or surgery is risking many patients.

Therefore to adequately provide services to these patients, they must be seen as patients who are in a life-threatening situation even if the bitch has the appearance of being stable. The staff must be empowered to make decisions on who can be rescheduled in general practice. Triage in emergency practices may require putting the pregnant bitch higher on the treatment list than the condition of the bitch alone would indicate if the pups are to be saved.

Your role in education, referrals and alternatives to conventional treatments

Remind your breeder clients that there are many procedures you offer as a licensed professional that they are not legally permitted to perform themselves. These vary from state to state and may include, but are not limited to administering rabies vaccinations and performing surgical procedures, such as ear crops and taildocks. Each state has its own veterinary practice act, which should be consulted if there is any question.

Help your clients cultivate the 8 skills they should have to become better breeders

You may ask why you should contribute to this aspect of assisting your breeder clients. Good question. Some will not require your assistance as they are skilled already. Some will not want your input. But most will need assistance at least with the veterinary aspects of which pup to sell, which to keep and which to breed. A complete physical examination of the patients and good written explanations of the exam findings and any abnormalities will be of great assistance to the breeder. We want our breeders to rely on us as the experts for their examinations and treatment planning. Use the skills and knowledge you have, and limit your services to what you know.

The following are skills you can help clients develop but are not skills you yourself will likely have or need to have first-hand knowledge of.

1. Know the breed standard

Each breeder should strive to know what their breed club has written as its “breed standard” – their ideal dog.

Illustrated standard

Many breed clubs not only have written descriptions but have included photographs and drawings of their standard. These can be found on-line or in published form from the breed clubs.

Mentor

Nearly every successful breeder has had someone take them under their wing early in their dog competition career. If you have the resources, assist fledging clients in hooking up with others in their breed or related breeds who would be interested in mentoring them.

Dog events

Locating and attending events is a great way to see many great specimens of their breed and network with others. Most areas also have all-breed clubs and single breed clubs that can be joined.

Internet

Many breed clubs have an on-line list or lists prospective breeders can join for advice and networking.

2. Breed knowledge

Know which lines "click"

This information is often found only as an oral tradition, discussed when breeders get together. It is better to find out from another's experience than to try the experiment again and again.

Identify and prioritize

Identify and prioritize the top 4 genetic problems in the breed: researching the breed on-line, through breed clubs, and in print can illuminate the most common disorders of a breed. As this can change from time to time, the breeder should continue to research their breed.

Focus on crippling, life-altering or fatal diseases first

These are the diseases that are the most damaging to the breed.

Avoid including genetic problems in the lines

Observation by the breeder, physical examination by the veterinarian, blood tests, radiographs, DNA testing and many other techniques exist or will exist in the near future to aid in selection.

3. Develop a method to select dams and sires

4. Pedigree analysis

Review the traditional AKC pedigree, the stick dog pedigree by Carmen Battaglia and the inheritance pedigree.

5. Develop a retrievable record keeping system

Complete paper or software records, photos and videos for each dog are essential.

6. Learn to evaluate litters

Sixty percent of dogs shown are not owned by the breeder, supporting the fact that many breeders sell the "wrong" dog, the one they should have kept.

7. Follow up all puppies at 6 months

Puppy parties (see chapter 2), videos and radiographs are all useful techniques. By doing this, the breeder can monitor the product of their breeding program.

8. Learn to manage, feed and condition a competition dog

Only 35% of a dog's presentation and appearance is genetic, 65% is management, nutrition, and training – aspects that the owner can control.

When to refer

Many conditions of the reproductive tract can be handled effectively by the general practitioner. However, there are some treatments that maintain fertility, such as medical therapy for pyometras, semen freezing, and alternatives to neutering for stud dogs with prostate or testicular disorders that are treatment options for the valuable breeding dog that are not first line treatments for pet dogs.

Some diagnostics and treatments, as well as complex breedings, are better handled by veterinarians who frequently deal with breeders and are skilled in these procedures or by board-certified Theriogenologists. In these cases, referrals to this group of veterinarians should be offered to the clients.

Screening for genetic selection

Dogs have been subjected to genetic selection ever since humans domesticated the dog. This is not new; this is how humans developed breeds intended for specific purposes over many centuries. However, here we are referring to a more sophisticated form of genetic selection.

Selection based on phenotype

This type of screening has been used for many years. There are two broad categories. First are general findings on physical examination of the dog. Second are specific disease-based screening tests developed by veterinary specialists to provide breeders with a standardized approach that can be used in evaluating their offspring and breeding stock.

General findings on physical examination

This is where the veterinarian or breeder classifies the dog's structure as normal, abnormal, or some gradation in between on physical characteristics found by examination (See Chapter 2).

Specific disease-based Screening Tests

These tests use the physical appearance of the dog to detect abnormalities. Perhaps the best known test in this category is the use of radiographs to screen for hip dysplasia utilizing OFA for analysis.

These specific evaluations are standardized and allow dogs to be certified in different categories so that the findings can be included in databases. These screenings are based on physical examination, radiographic and laboratory findings.

Selection based on genotype

There are four types of DNA tests: parentage tests, mutation-based tests, linked-marker tests and tests to identify the breeds but not the individual parents who contributed genetics to an individual dog. This type of genetic screening is the most rapidly evolving. Completion of the canine genome in 2004 and research at both commercial and non-commercial facilities is expanding the number of DNA tests exponentially. It is not likely that any veterinarian will be able to stay current with all of the available tests. Dog breed clubs will, however, have recommendations of the tests available for screening. Careful research into each test is needed to be certain that the test was evaluated for the breed in question before making a recommendation. DNA markers for one breed do not necessarily serve as the DNA marker for another breed. For our use in selecting potential breeding dogs, mutation-based tests and linked-marker tests provide diagnostic insights (See Chapter 2).

With all of these genetic findings available, the breeder may look to you for input on how to interpret the data and put it to use in their breeding program. Our clients trust us to aid them in limiting or eliminating genetic diseases in their breeding stock, while at the same time maintaining the diversity of their purebred dogs. Here is a great challenge for us as veterinarians: there is no genetically perfect dog; they all have at least one genotypic or phenotypic defect. And with the number of tests looming in our future, very few dogs will be candidates to be tested for every disorder for which a test exists. Our goal as consultants to our breeder clients is to assist them in making the best genetic decisions they can.

Veterinarians ARE the animal experts, the professionals our clients and the public put their faith in.

CHAPTER 2
Genetic Selection and Screening

Selecting breeding stock

As a veterinarian entrusted to aid a breeder, it is helpful to understand in general how breeders can be assisted as well as how individual breeders can use your expertise. You may be involved in selecting dogs to include, and more importantly, to exclude from a breeder's breeding stock. Most veterinary schools spend little time on teaching genetic counseling. Even if it was taught, the field has changed so rapidly, it is probable what was taught is now out of date.

To be most effective in this role, you will need to avoid the temptation to systematically eliminate every dog with a defect from the gene pool. This approach will quickly alienate the breeder who has come to you for assistance. The goal is not to say what the breeder wants to hear, but to aid them in selecting dogs to include in their breeding program to perpetuate the positive traits and eliminate the undesirable traits.

There are several flaws in systematically eliminating all dogs with a defect. First, our purebred dogs have been described as "endangered species" by Dr. Anne Traas. Pure-bred dogs cannot be interbred and still be considered pure-bred. If we keep dog breeds from intermingling (that is the purpose of the closed breed registries), each breed currently has all of the genetic material it will ever have. Genes cannot be gained by breeding, only eliminated. If we eliminate every dog with a defect, we will have few or no purebred dogs left in most breeds. Some breeds, such as the Otterhound, have less than 900 dogs world-wide; here there is already a dangerously small gene pool.

There is no perfect individual dog. By maintaining more dogs in the line, we maintain genetic diversity in the breed. We must not make the mistake of eliminating dogs with obvious but minor genetic defects (such as umbilical hernias and distichia) and inadvertently continue to breed dogs with more serious hidden defects (such as temperament concerns). So we must support and assist breeders in determining carefully how to select breeding dogs, not recommend the elimination of every dog with a defect.

Second, some individual dogs carry specific traits that are too valuable to the breed to be eliminated. A top-winning or high performing dog is often too highly valued, both emotionally and genetically, to be tossed out of a breeding program. Even if this top-winning dog carries or is affected by a genetic defect, it is not automatically "bad" genetically. These carrier or affected dogs are probably preserving essential genes. Remember, the defective gene was not created by the breeder, but by a genetic mutation. It then becomes magnified by "genetic bottlenecking" (repopulating a breed from a limited number of individuals) or "founder's effect", also known as popular sire syndrome (the disproportionate use of one individual in a breed, usually a male dog.). Most breeders have too much invested in a line of dogs just to start over. Neither the breeder nor the individual dog is to blame for the genetic defect. Random DNA mutations are the cause of genetic diseases.

One approach to classifying genetic disorders is to rank them in order of severity, arbitrarily numbered as below.

Group 1 disorders are genetic defects that are minor in their impact on the dog's health and owner's need for ongoing care. These are disorders such as umbilical hernias – these may require surgical repair (see AKC guidelines) but after correction, do not leave any lasting impact on the dog's health. These disorders are frequently the easiest of the three groups to detect, and are most often detected on the youngest dogs. It is too easy to mistakenly toss these dogs out of the gene pool; consider the option of leaving these affected dogs intact, allow them to grow up and later compare them with other dogs of their breed. The affected dog may turn out to have the least serious defect and the most valuable desirable traits, making them a valuable addition to their breed.

Group 2 disorders are genetic defects that are non-life threatening but have an ongoing impact on the dog's health and owner's need for ongoing care. Thyroid disease and, allergies are disorders that falls into this category – this requires lifetime medication and an ongoing expense but if well-managed, does not alter the dog's lifestyle or longevity.

Group 3 disorders are genetic defects that are life-changing disorders. These include seizures caused by epilepsy, genetic orthopedic disorders such as hip dysplasia, and temperament issues. Not only do these disorders require lifetime management, but they impact the dog's health, alter the lifestyle of the dog and owner, and often shorten the dog's life expectancy.

Using this type of classification is helpful to the client and veterinarian when determining if the individual dog should be included or excluded from the breeding stock.

Counseling the breeder/client

The best approach to adopt when providing genetic counseling for a breeder is to assist them in developing goals. Most breeders share the common goals of producing healthy dogs with longevity while either maintaining or improving their breed type. Within the same breed, breeders have their own opinions of what their breed should look like (breed type, conformation) and how they should perform (temperament and abilities). Once general goals are defined, more specific goals can be identified. The breeder should be encouraged to focus on correcting weaknesses in their pedigrees. The breeder can be aided in determining their personal thresholds for traits. Some traits are all or none, i.e. the dog must be free from a trait, i.e. cataracts, and other traits are on a continuum, i.e. hip scores. If the criteria the breeder establishes are too stringent, no or few dogs will be eligible to be bred, but if they are too lenient, improvement in their goals will be slow. A balance of all traits must be achieved; if only one trait is sought, too many other important qualities and traits may be eliminated from the line.

We can provide a valuable service to the breeder-client by helping them identify their goals. Diseases that most veterinarians and breeders identify for elimination from the breeding pool are those that cause death, are life-changing, or significant discomfort; or that have no available or affordable treatment options. Many geneticists suspect that a number of the diseases seen today have a genetic basis that has not yet been identified. In the future there will probably be DNA tests for diseases that at this time are not known to be genetic.

Some breeders forget when they breed a litter that most of the pups will end up as "pet" puppies, not show dogs. It is important that the pet puppies, those sold to families to become a beloved family member, must be of sound health and temperament. They must not knowingly produce pet dogs who will be difficult or dangerous to live with and/or that will be costly or impossible to provide with medical care.

On the rare occasion that a genetic defect is caused by a recent mutation which may only affect a small number of individuals, the breeder is well-advised to be severe in eliminating these individuals from their breeding program to avoid dispersing the new mutation into the whole gene pool. However, if a small-population breed (there are at least 44 recognized by AKC), has a wide-spread defective gene, breeders must systematically breed carriers to normals and gradually replace carrier breeding stock with normal-testing offspring. "Defective genes were not created by breeders. They are due to mutations, bottlenecking and founders effects in the development of breeds." (Bell, Jerold: "The Proper Use of Genetic Tests in Making Breeding Decisions." ESSFTA. Seattle, 28 Feb. 1998.)

As the number of genetic screening tests increase, breeders will have to determine which tests are appropriate for their individual situation. It will soon become cost-prohibitive to run all available tests on all breeding stock, unless these tests are "bundled". However, certain individuals within the breed,

such as frequently used sires, should be screened more intensively. An owner of a frequently used stud dog should first screen the dog for the most common and serious diseases in their breed, and then continue to screen for as many disorders as possible. Another consideration is to bank the frequently used stud dog's DNA to use for testing later as more DNA tests become available. DNA can be banked as blood (whole or dried on an FTA card) or as frozen semen. This is important whether the dog is retired or deceased and no longer siring pups or if the dog's semen is banked and he continues to sire pups long after his reproductive life is over.

It is generally the bitch owner who researches pedigrees and seeks out males for compatibility and desirability. The most common categories of traits sought are conformation (meaning appearance and structure), health, performance and temperament. Usually, all four are desired and must be balanced.

Pedigree analysis is an important aspect of stud dog selection. Pedigree depth is vertical when the generations of dogs listed in the pedigree are evaluated. Pedigree breadth is horizontal when the siblings of the bitch and sire are evaluated. Both analyses are important. Websites such as the OFA and CHIC websites are valuable resources in researching some of the test results breeders will want to analyze. Other sources are breeder and club websites, breed publications, and direct communication with other experienced fanciers of the breed.

There are many ways to sort through strengths and weaknesses of individual dogs when selecting an appropriate mate. Stud dog selection is based on many criteria.

The most frequently identified reasons breeders select a stud dog are:

1. Convenience – knowledge of and proximity to a stud dog.
2. Cost – the expense of the stud fee and semen shipment/insemination costs
3. Pedigree – the desirability of the ancestors
4. Offspring produced – the success of previous offspring

(Battaglia, Carmen: "Breeding Better Dogs Seminar." Greater Racine Kennel Club. Racine, Wisconsin. 19 Feb. 2005.)

One technique is described by Carmen Battaglia, in his "Breeding Better Dogs" book. This technique uses "Stick Dog" figures and a symbols pedigree to help the breeder visualize the strengths and weaknesses of an individual dog's traits. Using this method, the breeder can more easily select dogs for their breeding program with physical traits they want to incorporate into their line. This technique emphasizes only physical appearance, and does not incorporate important traits related to health.

George Padgett D.V.M., geneticist and professor of pathology at Michigan State University, was a strong supporter of breeders sharing information among themselves. He emphasized the importance of revealing not only the good qualities of a dog to the owner of a potential mate to that dog, but also the inferior qualities emphasizing traits related to health. There is little question that revealing genetic information to others in your breed is necessary to prevent breeding two dogs together that share an undesirable trait (doubling up on that trait). Unfortunately, the world of dog breeders is fiercely competitive and some breeders fear this honesty will give their dog an undeserved poor reputation and drive potential mates or buyers away from their line of dogs. It is important we as veterinarians support the honest reporting of disorders by both reporting it to the owner of the bitch or stud dog and supporting them in sharing the information with others. However, as professionals, we must only report this to the owner(s) of the dogs and not share the information directly or indirectly with members of the dog-owning public who are not privileged to have access to this information.

Traits such as temperament are subjective. Researching for phenotypic and genotypic tests is time-intensive. Breed clubs often have resources on their websites. The CHIC website (http://www.caninehealthinfo.org) lists many but not all AKC breeds and is a good place to begin. This research should be left for the breeder to initiate, allowing the veterinarian to become involved in discussing frequency, severity of the disease and delivery of the testing services.

If the breeder has questions or a severe problems that are beyond the scope of the primary care veterinarian, a consultation with a geneticist should be recommended.

Hybrid dogs

There is a current trend in breeding and puppy sales of producing hybrid or "designer dogs." This is nothing more than intentionally producing mixed-breed dogs. There is an apparent misconception that by mixing breeds, the outcome will produce healthier puppies. Unfortunately, most of the dog owners participating in this process are not screening their sires and dams for genetic disorders. Hybrid vigor is not automatic; mixing 2 or more breeds together arbitrarily will not automatically sort out the "bad" genes and leave in only the good genes. If this were the case, practicing veterinarians would see only purebred dogs – the mixed breed dogs would be in perfect health and never need veterinary care. Of course, we all know that this is not the case.

Breeding "designer dogs" will produce dogs of unpredictable temperament, random size, and unpredictable health problems. Randomly mixing genetics from one breed of dog with another is likely to lead to more health and temperament problems than it solves since these dogs are usually not screened to prevent passing along known inherited diseases.

DNA and the canine genome

In 2004, the collaborative effort of many researchers culminated in discovering the canine genome. At the time of publishing, approximately 50 of the more than 360 known canine genetic diseases had DNA tests available. However this number is likely to increase exponentially. This increase will make it difficult and cost-prohibitive to have every individual screened for every disorder. However, by understanding the inheritance of disorders, veterinarians and breeders may identify key foundation dogs in the pedigrees and be able test only a limited number of dogs. When foundation dogs are available and can be identified as clear of a disorder, offspring may not need to be tested.

Researching the genetics of individual breeds

In the United States, breed clubs generally make recommendations but rarely mandate testing for specific traits or diseases. Recommendations may be based on the frequency and/or the severity of the disease. For instance, hip dysplasia affects 30 % or more of large breed dogs, so the frequency and severity of the condition drives the desire to screen for the disease. Other disorders, such as epilepsy, may be less frequently seen but it is a highly undesirable trait in a genetic line, due to both the emotional and financial cost of controlling the disease. For these reasons epilepsy too is an example of a disorder breeders strive to breed out of their lines.

The CHIC website (http://www.caninehealthinfo.org/), breed specific parent club websites, and website for institutions and companies offering DNA testing are excellent and up-to-date resources of tests suggested and currently available.

CHIC is co-sponsored by the OFA and the AKC Canine Health Foundation. CHIC works with parent clubs to identify health screening protocols appropriate for individual breeds and serves as their fee-based database. Dogs that are tested in accordance with the parent club established requirements, that have their results registered and made available in the public domain are issued CHIC numbers. CHIC's purpose is to encourage uniform health testing and sharing of all results, normal and abnormal, so that more informed breeding decisions can be made in an overall effort to reduce the incidence of genetic disease and improve canine health.

Selection based on phenotype

Phenotypic screening has been used for many years while genotypic testing, the gold standard for

screening for genetic defects, is relatively new. However, most identified defects do not have a DNA test available. Until DNA genotype tests are available for more disorders and traits, we will continue to use phenotype testing.

There are two broad categories of phenotypic testing. First are the general findings on physical examination of the dog. Second are specific screening tests developed by veterinary specialists to provide breeders with a standardized approach they can use in evaluating their offspring and breeding stock. Perhaps the best known phenotype testing is the use of radiographs to screen for hip dysplasia utilizing OFA for analysis.

Physical evaluation for phenotypic abnormalities

General findings on physical examination

You do this every time you examine a litter of puppies or an adult dog that the owner is considering using for breeding, but you may not have thought of it this way before. This is a very economical method for breeders to screen for physical abnormalities. You and the breeder will both be doing phenotypic analysis, but you will be looking for different traits than the breeder will. You will be looking for undesirable traits such as a heart murmur, and they will be looking for traits such as the shape of the eye or the tailset. Both are important in selecting breeding stock.

The veterinary examination of adult or young dogs includes:

1. Evaluation of vital signs. Normal pups by 6 weeks and older should have a normal body temperature of 101.0° to 102.5°, heart rates of 100 to 250 beats per minute and a respiratory rate of 30 to 50 breaths per minute. Mucus membrane color may be slightly paler than in the adult as many pups have a normal physiological anemia.
2. Evaluation of the dentition. This includes the size and shape of the jaw, alignment of the incisor and canine teeth, and evaluation of the interdigitation of the premolars. It is believed the upper and lower jaws can be influenced by different genes and therefore grow at different rates. Alignment may change up to 8 months of age and older. In many breeds, having complete dentition is also a factor.
3. Evaluation of the oral cavity. The pup should be evaluated for a complete hard and soft palate and normal swallowing reflexes. Evaluation for elongation of the soft palate nearly always must be done with general anesthesia and is not part of a typical comprehensive physical examination. The size of the trachea is a valuable evaluation for the brachycephalic breeds, but as it requires a lateral thoracic radiograph for evaluation, this is also not part of a routine physical examination.
4. Evaluation of the nares includes the size of the nostril opening. No breed standards have specific requirement for this, but appearance of the dog can be influenced by this. As a matter of function, nostrils that are stenotic can impair the dog's respiratory capabilities.
5. Evaluation of the eyes. A complete examination for ERC or CERF requires the services of a board-certified veterinary ophthalmologist. However, some abnormalities are detectable by simple visual examination with good lighting and magnification. These include distichia, persistent pupillary membranes, dermoids, entropion and ectropion, epiphora, everted nictitans, and microophthalmia. Pups should be observed during the evaluation to assure that they have normal vision. Eye size and shape may be important to the breeder but is not usually clinically significant.
6. Evaluation of the ears. The ears should be evaluated for the presence of a complete pinna and ear canal on both sides of the head. Ear size, shape, and position are important to the breeder but few ear abnormalities are clinically significant. Hearing tests are addressed by BAER testing, described below.
7. Evaluation of the limbs. Pups should be observed on the floor to be certain that they have normal locomotion. With a few breed specific exceptions, the pups should not have deviation of the forelimbs – the front toes should point forwards. Some breeders are reluctant to allow

their pups to be placed on the floor at the veterinary clinic, so this is a challenge you may need to overcome to allow for complete evaluation. Limbs should be palpated for symmetry and swellings. The feet should be evaluated to be certain that all toes and footpads are present. Older pups can be evaluated with palpation for normal elbows and shoulders. You may be asked to check pups hips for an Ortolani sign. Patellar location and laxity can be assessed in even the very young puppy.

8. Evaluation of the thorax. The lungs should be clear on auscultation and the heart should be normal. Careful auscultation of the heart is essential. Both sides of the thorax should be evaluated, with the stethoscope placed over each valve. This can be difficult to achieve with a wiggly puppy and a room full of active littermates. It can be helpful to hold the pup in your lap or you may even leave the room with the pup so the pup and you are less distracted. Offering the pup baby food to lick can keep them more still during auscultation. The new electronic stethoscopes make detecting subtle murmurs much less challenging.

   An undetected heart murmur can lead to difficulties for you and the breeder if the pup is found to have a murmur by the new owner's veterinarian. Be very thorough in your auscultation. Any murmur, even grade 1 murmurs, must be reported to the breeder as they may intensify as the pup ages.

   Some murmurs are innocent murmurs and may disappear by 12 weeks of age. Some murmurs are so loud they are suspect from the first visit. If a pup is found to have a murmur, it is recommended the pup be held for subsequent evaluation or sold with full disclosure. If the murmur has not resolved by 12 weeks of age, the pup is smaller than its littermates, or if the pup seems to be exercise intolerant, a prompt referral to a veterinary cardiologist is recommended for a full cardiac evaluation.
9. Evaluation of the abdomen. The abdomen should be soft on abdominal palpation with no masses or intestinal abnormalities noted. Ropey intestines or pot-bellied appearance are a frequent finding in pups who have not been adequately treated with anthelminthics. The ventral abdominal wall should be evaluated for both umbilical and inguinal hernias. It may be useful to place gentle pressure on the mid-abdomen to detect small hernias. Small reducible hernias may resolve spontaneously but should be noted regardless as these are inherited and both the breeder and prospective puppy owner should be made aware of their presence.
10. Evaluation of the rectum. It is possible but unlikely that a young pup can have an incomplete GI tract and no rectum. If feces are found on the rectal thermometer, a complete GI tract can be assumed.
11. Evaluation of external genitalia.

    a. Male puppies should have their penis and testes evaluated. Both testes should be present in the scrotum by 3 weeks of age. If there is family history of penile defects, such as phimosis, penile frenulum or hypospadia, or there are abnormalities noted with urination, the penis should be exteriorized for visual examination. If the bladder is distended, the pup should be observed for urination because some very young male pups may develop urinary calculi and obstructive diseases.

    b. Female puppies should be carefully evaluated for location and size of the vulva and os clitoris as well as for vaginal discharge. The vulva is frequently small or more ventrally located than in the adult. If the os clitoris is enlarged or prominent, the possibility of an intersex pup should be considered. Many female pups have mild to moderate vaginal discharge associated with mild puppy vaginitis. This is not serious and may not require treatment unless the pup has clinical signs of urinary tract disease or discomfort.
12. Evaluation of the tail. The tail may be complete or shortened either by surgical docking or a genetic shortening. Clinically significant defects in the tail include kinks and skin folds. In most cases, the tail length and position is not of clinical significance.

Temperament and performance traits

Temperament qualities and desired performance traits vary with each individual breed and the preferences of each breeder. This is a subjective evaluation; there are no rules and no database. Current understanding of ethology suggests that temperament is a highly inherited trait. These decisions are generally made by the breeder and their network of fellow dog breeders. In some situations, veterinary participation and referral to a behaviorist with these skills may be beneficial to the breeder.

Longevity

Many traits, both physical and behavioral, play a role in achieving this goal. There is no one test or way to select for this.

Specific disease-based screening examinations and their respective databases

This type of evaluation uses the physical findings (phenotype) of the dog to detect abnormalities in its genetic make-up. Although DNA tests for specific diseases are the preferred method of screening for genetic diseases, in the absence of DNA tests, phenotypic evaluations are the only alternative. Applying results from the sire and dam, along with information on other close relatives such as siblings, half-siblings, aunts and uncles allows breeders to apply greater selective pressure to produce normal offspring and avoid affected offspring.

These specific tests are standardized evaluations. This permits breeders to compare dogs to an ideal standard and to one another. In some cases, the results are released only to the breeder, but in others, the results are included in databases. These screenings include findings based on physical examination, radiographs and laboratory testing. General information and websites will be included here to introduce each current category to the practicing veterinarian. Prior to a client visit requesting these screenings, it would be beneficial to visit the website and familiarize yourself with the tests requested.

Most of these tests are evaluations a general veterinary practitioner can offer as a service to their clients. Several evaluations, however, require specialized training and/or equipment and will require a referral to specialists. Many experienced breeders have already developed a network of preferred specialists and expect to visit several veterinarians to complete their screening prior to the sale of puppies or placing an individual dog in their breeding program.

Phenotypic screening

CERF (Canine Eye Registration Foundation) exams and ECR (Eye Certification Registry)

This is a complete ophthalmic examination, which must be completed by a board-certified veterinary ophthalmologist (a member of the ACVO). Upon completion of the examination, a form is prepared indicating normal and abnormal findings. A dog with normal findings or some limited abnormalities will be registered with ECR or CERF upon submission of the form and the appropriate fee. Breeding advice will be offered based on guidelines established for that particular breed by the Genetics Committee of the ACVO for dogs with abnormalities noted on examination.

There is great variation in the type of eye disorders and age of onset in different dog breeds. Therefore, there is great value in repeating the opthalmic examinations periodically throughout the life of any dog in a breeder's line that have offspring in an active breeding program. This certification is good for 12 months at a time so the dog must be reexamined and recertified to maintain its'

registration with ECR or CERF. Patients can be as young as 6 weeks of age for their first evaluation and there is no upper age limit. Some breeders will have ophthalmic examinations completed prior to selling puppies as pets. As of January 1, 2001, patients are required to have permanent identification in the form of a microchip, DNA profile, or tattoo to be registered with ECR or CERF. Both will certify the eyes of normal hybrid dogs.

ECR and CERF exams are done on a regular schedule at most veterinary ophthalmologist's offices. They are also frequently held in conjunction with other canine performance events at the performance locations. Many breeders find it more convenient to attend an eye clinic.

ECR and CERF also maintains a data base based on dog breeds. This information will be used in generating research reports, but the individual dog's identities will become confidential and will never be released. CERF also has a publication called "OCULAR DISORDERS PRESUMED TO BE INHERITED IN DOGS." The 5th Edition, 2007 version is available on CD and is a valuable resource when assisting breeders in decisions about breeding programs. Additional information on CERF can be found at www.vmdb.org/history.html. Information about ECR can be found at www.offa.org.

OFA cardiac database

The purpose of the OFA cardiac database is to identify dogs which are phenotypically normal prior to inclusion in a breeding program. For the purposes of the database, a phenotypically normal dog is defined as either one without a cardiac murmur or one with an innocent heart murmur that is found to be otherwise normal by virtue of an echocardiographic examination which includes Doppler echocardiography. If a murmur is detected on evaluation, referral for echocardiography should be recommended both for the health of the patient and the information gathered for the breeding program. Murmurs are graded 1 through 6. These and other descriptive terms for murmurs may be found on the OFA cardiac website at www.offa.org/cardiacgrade.html.

Cardiac auscultation is the primary screening method for initial identification of Congenital Heart Disease (CHD) and the initial classification of dogs. This evaluation is completed by cardiac auscultation at rest and may include additional auscultation after exertion to detect murmurs. Complete instruction on how this examination should be performed is available on the OFA website. It may be performed by Board- Certified Cardiologists (preferred) (suffix on OFA number of C), internists or other Specialists (suffix S) or by General Practitioners (suffix P). In addition, Echocardiograms and/or Holter monitoring may be recommended for some breeds. (See following sections on testing for arrhythmias and echocardiographic exam.)

There are many forms of congenital heart disease in dogs which are caused by malformations of the heart or great vessels. The lesions characterizing congenital heart defects are present at birth and may develop more fully during perinatal and growth periods. Many congenital heart defects are thought to be genetically transmitted from parents to offspring; however, the exact modes of inheritance have not been precisely determined for all cardiovascular malformations. At this time, inherited developmental cardiac diseases like subaortic stenosis and cardiomyopathies are difficult to monitor since there is no clear cut distinction between normal and abnormal. The OFA states it plans to modify the congenital cardiac database when a proven diagnostic modality and normal parameters by breed are established. However at this time, the OFA cardiac database should not be considered as a screening tool for SAS or cardiomyopathies. Current information regarding the OFA cardiac database can be located at: http://www.offa.org/cardiacinfo.html.

OFA patellas

Patellar luxation can occur either in a medial or lateral position and may be either bilateral or unilateral. This disorder occurs in many breeds. Dogs can show symptoms as early as 8 weeks of age. In some cases, the affected dog has abnormal limb carriage from the time they begin to bear

weight at 3 weeks of age. Frequently, the dogs have a knock-kneed (genu valgum) stance and the foot can be seen to twist laterally as weight is placed on the limb. In many cases, the dog presents acutely lame, often painful and non-weight-bearing on the first episode. The patella is usually reducible, and laxity of the medial collateral ligament may be palpable. The medial tissues of the stifle joint are often thickened.

Patellar luxation is diagnosed by palpation of the position of the patella with mild manipulation performed by any qualified veterinarian. Radiographic studies are not included in this evaluation. Evaluation of the patellar position can be done as early as 8 weeks of age. The patient should not be sedated and must be at least 12 months of age to be included in the database. Re-evaluation later in life is encouraged as some luxations become evident as the patient ages. The patella is classified as either being in a normal position, or if it is luxated, is categorized by grade. To receive OFA patellar certification, the patient is examined, the appropriate form is completed including the veterinarian's findings, signed by the veterinarian, and submitted to OFA with the associated fee. OFA encourages submission of all evaluations, normal or abnormal but does not charge a fee for abnormal patellar evaluations.

A method of classifying the degree of luxation and bony deformity is useful for diagnosis, and can be applied to either medial or lateral luxations by reversing the medial-lateral directional references. The position of the patella can easily be palpated starting at the tibial tubercle and working proximal along the patellar ligament to the patella.

Grade 1 patellar luxation

Manually the patella easily luxates at full extension of the stifle joint, but returns to the trochlea when released. No crepitation is apparent. The medial, or very occasionally, lateral deviation of the tibial crest (with lateral luxation of the patella) is only minimal, and there is very slight rotation of the tibia. Flexion and extension of the stifle is in a straight line with no abduction of the hock.

Grade 2 patellar luxation

There is frequent patellar luxation, which, in some cases, can become permanent. The limb is sometimes carried, although weight bearing routinely occurs with the stifle remaining slightly flexed. Especially under anesthesia it is often possible to reduce the luxation by manually turning the tibia laterally, but the patella reluxates with ease when manual tension of the joint is released. As much as 30 degrees of medial tibial torsion and a slight medial deviation of the tibial crest may exist. When the patella is resting medially the hock is slightly abducted. If the condition is bilateral, more weight is shifted onto the forelimbs.

Many dogs with this grade live with the condition reasonably well for many years, but the constant luxation of the patella over the medial trochlear ridge of the trochlea causes erosion of the articulating surface of the patella and also the proximal area of the medial lip. This results in crepitation becoming apparent when the patella is luxated manually.

Grade 3 patellar luxation

The patella is permanently luxated with torsion of the tibia and deviation of the tibial crest of between 30 degrees and 50 degrees from the cranial/caudal plane. Although the luxation is not intermittent, many animals use the limb with the stifle held in a semi flexed position. The trochlea is very shallow or even flattened.

Grade 4 patellar luxation

The tibia is medially twisted and the tibial crest may show further deviation medially with the result that it lies 50 degrees to 90 degrees from the cranial/caudal plane. The patella is permanently luxated. The patella lies just above the medial condyle and a space can be palpated between the

patellar ligament and the distal end of the femur. The trochlea is absent or even convex. The limb is carried, or the animal moves in a crouched position, with the limb flexed.

Patellar luxations fall into several categories. The first 3 are either known to be or suspected to be inherited. Medial luxations occur in toy, miniature, and large breeds. These patients have anatomic deformities that cause luxation. Lateral luxation occurs in toy and miniature breeds. These patients usually present in middle age. Lateral luxation occurs in large and giant breeds. These dogs usually present at 5 to 6 months of age, are usually affected bilaterally, and may have associated hip dysplasia. Luxation resulting from trauma occurs in various breeds, and is of no importance to the certification process. Unless there is deviation of the tibial crest, it may be difficult to differentiate traumatic from congenital patellar luxation. (See www.offa.org)

Testing for arrhythmias

Use of a 24 hour ECG using a Holter monitor is currently the preferred evaluation when testing a dog for arrhythmias. The Holter allows the monitoring over a period of approximately 100,000 heart beats, increasing the opportunity of detecting intermittent arrhythmias. Dogs which show runs of PVC's are at increased risk for syncope or sudden death. It is presumed there is an inherited component to this disease and in some breeds, screening for PVC's is recommended prior to breeding (Figure 2-1).

There are services that provide the equipment and interpretation of the results by a Board-certified Cardiologist. In general, breed clubs have already made these arrangements.

Figure 2-1.
Holter monitor for cardiac arrhythmias.

Screening for deafness

Congenital deafness in dogs (or other animals) can be acquired or inherited. Inherited deafness can be caused by a gene defect that is autosomal dominant, recessive, or may involve multiple genes. Congenital deafness has been recognized in approximately 80 dog breeds, but has been noted to be over-represented in dogs with white pigmentation. Two pigmentation genes in particular are often associated with deafness in dogs: the merle gene and the piebald gene.

A BAER test (the Brainstem Auditory Evoked Response) is necessary and is the only accepted method to identify dogs with partial or unilateral hearing deficits. Facilities that perform the BAER are usually only available at veterinary schools or specialty practices and are usually performed by a Board-Certified Neurologist.

Testing is done on dogs a minimum of 35 days of age. One test is all that is necessary for the dog's lifetime. Chemical restraint is administered at the discretion of the veterinarian performing the evaluation. Only dogs with bilateral hearing are classified as passing the test. The submission includes a printed copy of the BAER tracing complete with the dog's name or identification, the completed application form, and the appropriate fee.

The decision on how to proceed with a breeding program in which deaf individuals are identified should include researching the inheritance pattern in the breed and the pedigrees of affected individuals.

Screening for inherited liver shunts

Inherited liver shunts are found in 5 of every 1000 dogs. Most are small breed dogs. Breeds affected include Havanese, Yorkshire Terriers, Maltese, Dandie Dinmont Terriers, Pugs, Miniature Standard Schnauzers, Shih Tzus, Bernese Mountain Dogs, and Bichen Frises. Yorkshire Terriers, Cairn Terriers, Irish Wolfhounds, and Maltese have a proven hereditary basis. Research shows it is not a simple autosomal recessive mode of inheritance.

Testing all potential breeding stock of breeds at risk has been proposed. Testing involves paired fasting and 2 hour post prandial bile acids and blood ammonia levels. Not including dogs with elevated levels of either has been proposed as a method to eliminate phenotypically affected dogs from the gene pool.

Radiographic and ultrasound findings

OFA hip dysplasia

Hip dysplasia is a serious genetic disease which has been reported in every dog breed, in mixed-breed dogs and cats. Many veterinarians think that every dog, regardless of breed, should be evaluated radiographically for hip pathology prior to use in a breeding program. By contrast, many breeders consider their breed to be unaffected and do not screen for this. Hip dysplasia manifests as arthritis, pain and debilitation caused by the inherited abnormal biomechanics of an abnormally developed hip joint. Of significance is the lack of correlation between radiographic findings and clinical findings (Figure 2-2).

Radiographs for an OFA (Orthopedic Foundation for Animals) hip study are taken by the breeder's choice of veterinarian. The dog must be in the required dorsally recumbent, hip extended position. The view must include the wings of the ilium and patellas. The properly positioned, identified and exposed radiograph, completed application form, copy of the AKC certificate (or other registry if available) and appropriate fee are submitted to OFA either by mail or electronically. If the radiograph is sent by mail, it is prudent to send it with a tracking number so the film can be located if lost. The application form, detailed instructions on the correct positioning, and required film identification are included on the website: www.offa.org. If the patient is not positioned correctly, the exposure is not correct, or the film is not permanently identified, the radiograph will not be accepted by OFA and it will be necessary to repeat the study.

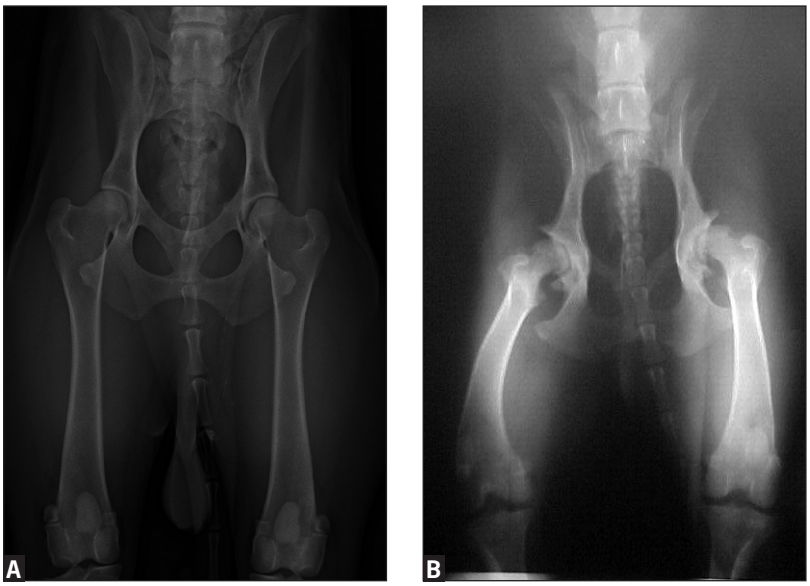

Figure 2-2.
A. *VD Pelvis position, OFA excellent hips. Also the position for the first of 3 required PennHip views. Wings of ilium and patellas visible on view, bilateral symmetry, femurs parallel.* ***B.*** *VD Pelvis position- dysplastic hips.*

To apply for an OFA number, the dog must be a minimum of 2 years of age. Preliminary evaluations can be submitted from ages 4 months to 2 years of age. Discounts are available if multiple films are submitted together. Results for accepted applicants are available approximately 4 weeks after submission.

As of January 1, 2001, OFA started requiring permanent identification (tattoo or microchip which must be verified by the veterinarian taking the radiograph if they have signed it was verified) for inclusion in their database. These identified animals will have a suffix of "PI" following their OFA number if one is issued. Animals without permanent identification will still be evaluated but will not be listed in the database and their OFA number will have "NOPI" as a suffix.

OFA recommends but does not require sedation or anesthesia to take radiographs. This is left to the discretion of the attending veterinarian and the owner of the dog.

In one small study, it was shown that some females show laxity of the hips around the time of estrus and whelping. It is not recommended to take radiographs of pregnant females. The OFA recommends radiographing three to four weeks before or after the heat cycle, and three to four weeks after weaning a litter of puppies. (See PennHip® study on this in the following section).

Results are provided by a consensus of three veterinary radiologists. Each radiologist will grade the hips with one of seven different physical (phenotypic) hip conformations: normal which includes excellent, good, or fair classifications (which are issued OFA numbers); borderline; or dysplastic which includes mild, moderate, or severe classifications (which are not issued OFA numbers).

OFA suggests the following use of hip dysplasia information for breeders in selecting breeding stock and mates:

- Breed normals to normals
- Breed normals with normal ancestry
- Breed normals from litters (brothers/sisters) with a low incidence of HD
- Select a sire that produces a low incidence of HD
- Replace dogs with dogs that are better than the breed average
- OFA fair dogs with 75% normal siblings are good breeding prospects if other genetic factors support inclusion in a breeding program.

Many breeders and dog handlers find early information of the hip status of puppies to be valuable. Early screening can permit early selection of dogs suited for show, performance, and breeding; this minimizes financial and emotional losses should dogs selected without this data fail to pass OFA ratings as they mature. Preliminary hip evaluations are accepted by OFA as early as 4 months of age. These preliminary films are read only by the OFA staff veterinary radiologists and are given the same hip grades as other OFA cases. As of May 1, 2004 the dog must be at least 12 months of age at the time of the radiograph, and permanently identified via microchip or tattoo before the preliminary results can be published (this should be verified by the veterinarian at the time the radiograph is taken).

Dr. Corley of OFA published a comparison of the reliability of the preliminary evaluation hip grade phenotype with the 2 year old evaluation in dogs. There was 100% reliability for a preliminary grade of excellent being normal at 2 years of age (excellent, good, or fair). There was 97.9% reliability for a preliminary grade of good being normal at 2 years of age, and 76.9% reliability for a preliminary grade of fair being normal at 2 years of age. Reliability of preliminary evaluations increased as age at the time of preliminary evaluation increased, regardless of whether dogs received a preliminary evaluation of normal hip conformation or HD. For normal hip conformations, the reliability was 89.6% at 3 to 6 months, 93.8% at 7 to 12 months, and 95.2% at 13 to 18 months. These results suggest that preliminary evaluations of hip joint status in dogs are generally reliable. However, dogs that

receive a preliminary evaluation of fair or mild hip joint conformation should be reevaluated at an older age (24 months). Additional information on hip dysplasia, film submission, hip evaluation, and fees is available at www.offa.org.

OFA Legg-Calve-Perthes

Legg-Calve-Perthes Disease (LCP), also known as avascular necrosis of the femoral head, is seen in the hip of dogs and humans. In dogs, it is seen in young small breed dogs between 4 and 12 months of age. Dogs usually present with unilateral pain and lameness, but can have bilateral disease. LCP is believed to be an inherited disease, although the mode of inheritance is not known.

Radiographs,taken in the standard hip extended ventrodorsal view, show changes in the femoral head and neck. Dogs must be a minimum of 12 months of age on the date of the radiograph to be eligible for an LCP number. The radiographs may be taken by any veterinarian, but must contain the required dog identification as a permanent part of the radiograph, be properly positioned, and must be of sufficient quality for the OFA to reach a diagnosis. The application form, fee and radiographs are submitted for evaluation. Phenotypically normal dogs are assigned an OFA Legg-Calve-Perthes number.

OFA elbows

In 1990, OFA began to provide a service to evaluate elbows. Elbow dysplasia is a general term used to classify inherited pathology of the elbow. Four specific etiologies make up this disease and they can occur independently or in conjunction with one another. These etiologies include:
1. Pathology involving the medial coronoid of the ulna – fragmented coronoid process or FCP.

2. Osteochondritis of the medial humeral condyle in the elbow joint or OCD.

3. Ununited anconeal process or UAP.

4. A fourth cause of elbow pathology is premature ulnar growth plate closure, an inherited disorder in some chondrodysplastic breed. This condition may also be caused by trauma to the open growth plate in a young dog of any breed (Figure 2-3A and B).

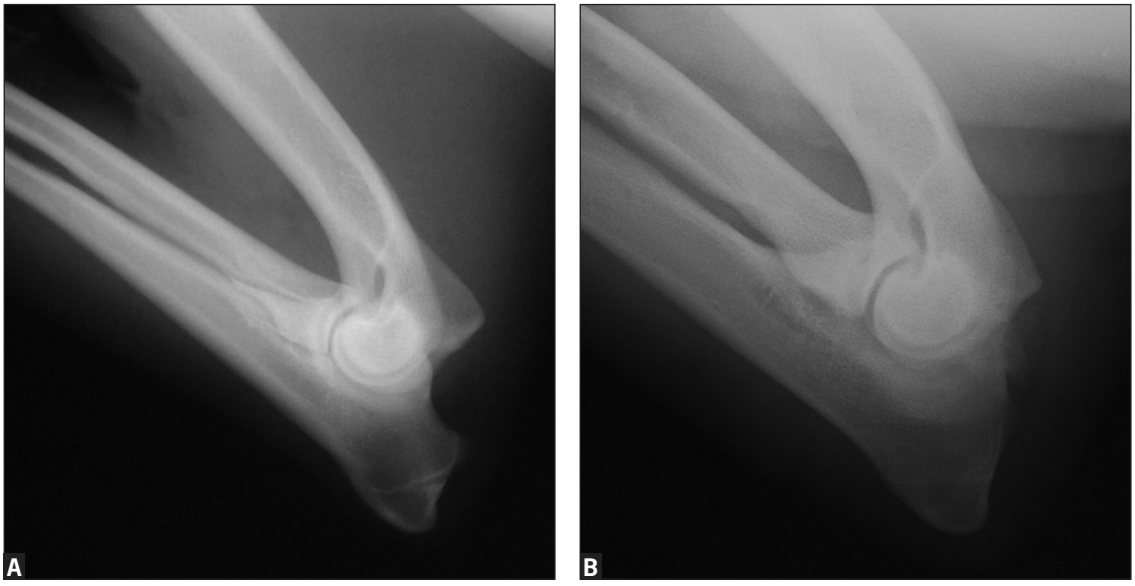

Figure 2-3.
A. *Lateral flexed view of elbow, OFA elbow normal.* ***B.*** *Lateral flexed view of elbow, OFA dysplatic elbow.*

The inherited polygenic traits that cause elbow dysplasia are unrelated to one another. Onset of clinical signs may be related to trauma, severity of the changes, and weight gain. Clinical signs, which may appear at nearly any age, range from slight gait changes, inward deviation of the foot, decreased range of motion of the elbow, to severe lameness.

The view required by OFA to diagnose secondary degenerative changes in the elbow joint is an extreme flexed medio-lateral view of the elbow. When there is instability of the elbow joint due to elbow dysplasia, it leads to a of new bone proliferation (osteophytes) on the anconeal process of the ulna) associated with secondary developmental degenerative joint disease.

For elbow evaluations, there are no grades for a radiographically normal elbow. The only grades assigned are for abnormal elbows with radiographic changes associated with secondary degenerative joint disease. Like the hip certification, the OFA will not certify a normal elbow until the dog is 2 years of age. The appropriate positioning, a well-exposed radiograph with the required permanent identification included on the film, and necessary application form and fee must be submitted to OFA for a rating to be issued. The OFA also accepts preliminary elbow radiographs. To date, there are no long term studies for preliminary elbow examinations like there are for hips. However, preliminary screening for elbows along with hips can also provide valuable information to the breeder.

OFA provides the following rating for abnormal elbow radiographs:

Grade I Elbow Dysplasia shows minimal bone change along the anconeal process of ulna (less than 3 mm).

Grade II Elbow Dysplasia shows additional bone proliferation along the anconeal process (3 to 5 mm) and subchondral bone changes (trochlear notch sclerosis).

Grade III Elbow Dysplasia shows well developed degenerative joint disease with bone proliferation along the anconeal process being greater than 5 mm.

OFA hip and elbow follow-up

OFA has recently begun to offer a new resubmission service. For a small fee, OFA will provide a "Follow-up Study" for hip and elbow studies taken later in a pet's life. The film will be read only by the OFA board-certified in-house veterinary radiologist. Owners will receive a report of the findings. The results from these "Follow-Up Studies" will not alter or risk the earlier official OFA consensus reading on which the dog may have received a hip or elbow number. The primary benefits of this new service are twofold: 1. the OFA will generate additional information on changes in hip status over the lifetime of the animal, and 2. owners will benefit from the same information without risking the earlier rating assigned by the OFA. Specific information on this service is available at www.offa.org.

OFA shoulders

This study is to evaluate for ostoechondrosis (OCD) of the shoulder. OCD is a disruption in the ossification of the cartilage mold under the articular cartilage of the joint. OCD has been reported in many joints, most commonly the shoulder, but also in the elbow, stifle, hock, and spine. It can appear to be unilateral or bilateral. Typically, affected dogs are large breeds, show clinical signs at less than 1 year of age, and males outnumber females. OCD is considered a genetic disease although the mode of inheritance has not yet been established (Figure 2-4).

To receive an OFA number for shoulders, the dog must be a minimum of 12 months of age. Preliminary evaluations are also available. As with other OFA studies, the patient must be appropriately positioned, the film must have the patient identification permanently as part of the radiograph, the film must be properly exposed, and all fees and signed paperwork must be included in the submission.

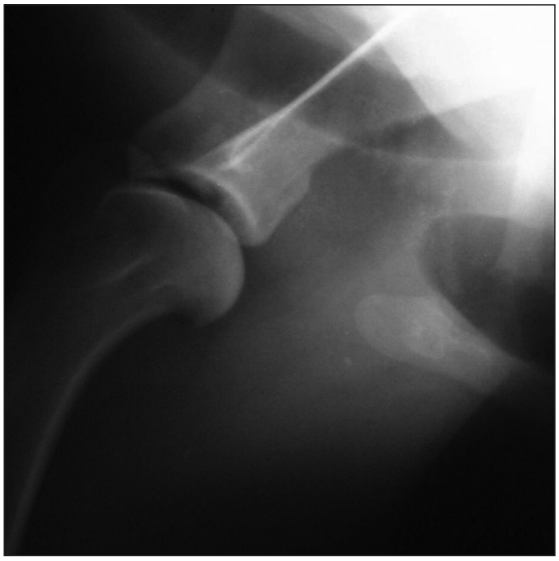

Figure 2-4.
Lateral shoulder view, OFA shoulders normal.

PennHIP®

PennHIP® (University of Pennsylvania Hip Improvement Program) uses a radiographic technique to assess the quality of the canine hip and quantitatively measures canine hip joint laxity. Only PennHIP® trained member veterinarians are qualified to take radiographs to submit for evaluation. Three views of the hip are taken with the patient under general anesthesia. The first view, the standard hip-extended view, is used to evaluate for DJD. The second view is used to evaluate hip joint congruity with the hip in a compression view. The third view is used to make quantitative measurements of the hip joint laxity in a distracted view. This set of 3 films is submitted to the University of Pennsylvania for analysis, providing results in a numeric format called a "distraction index." This is based on the theory that a joint with greater laxity (i.e. a higher distraction index or a number closer to 1) will lead later in life to a higher likelihood that the patient will develop more severe DJD than a patient with less joint laxity (i.e. a lower distraction index or a number closer to 0) (Figure 2-5A and B).

This diagnostic procedure may be done on patients as young as 16 weeks of age to produce reliable results. Unlike OFA, all patients who undergo a PennHIP® evaluation must be under general anesthesia and all radiographs taken must be submitted to PennHIP® for assessment, regardless of how obvious the pathology may be. This is to prevent skewing of the data collected by selectively withholding films to PennHIP® on affected dogs.

In 1997, PennHIP® completed a study to assess for laxity of the hips of female dogs related to estrus. The study showed the rise in hormone levels during the heat cycle does not affect hip laxity as measured by PennHIP®. However, hormones released during the birthing process and during lactation can increase hip laxity and hip evaluation at this time is therefore not recommended. PennHIP® recommends waiting 8 weeks post lactation or 16 weeks post whelping, before a PennHIP® evaluation.

Additional information regarding training to become a PennHIP® certified veterinarian, equipment required, and the research that supports this analysis is available at www.pennhip.org.

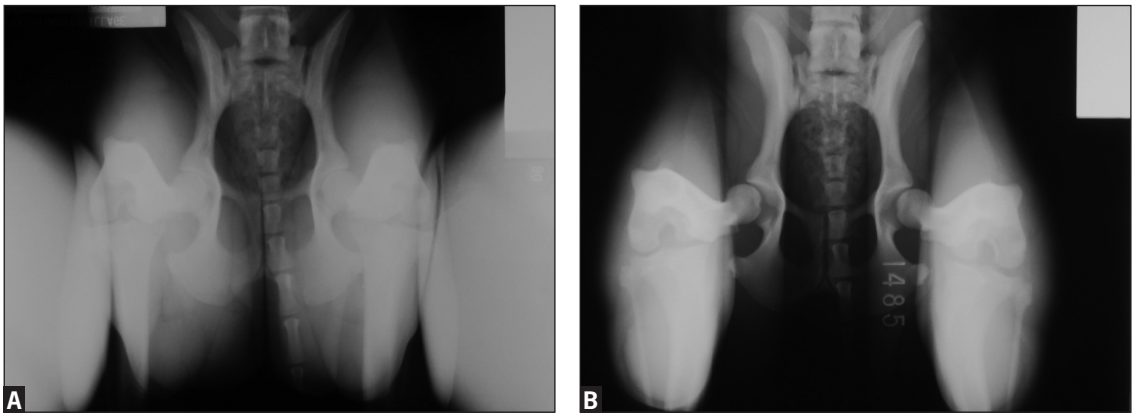

Figure 2-5.
A. *PennHip Compressed view - the second of 3 PennHip views required.* ***B.*** *PennHip Distracted view – the third of 3 views required.*

Echocardiographic (Echo) exam

There are some breed clubs which recommend an Echo be performed instead of or in addition to Holter monitoring prior to a dog entering the breeding pool.

For most veterinarians, the Echocardiographic exam will be a referral case. Board certification by the American College of Veterinary Internal Medicine, Specialty of Cardiology, is considered by the American College of Veterinary Medical Associations as the benchmark of clinical proficiency for veterinarians in clinical cardiology, and examination by a Diplomate of this Specialty Board is recommended. Other veterinarians may be able to perform these examinations provided they have appropriate equipment and have received advanced training in echocardiography. The examiner must be able to perform two-dimensional, pulsed-wave Doppler, and continuous wave Doppler examinations of the heart. The availability of color Doppler is valuable but not essential for most examinations. Echocardiographic studies should be reported on videotape for subsequent analysis and a written record of abnormal findings should be entered into the medical record.

Laboratory test findings for enzyme or hormone levels

Thyroid testing

Autoimmune thyroiditis is the most common cause of primary hypothyroidism in dogs. If the dog develops autoantibodies at any time in the dog's life, this is an indication that the dog probably has the genetic form of the disease. This disorder tends to appear clinically at 2 to 5 years of age. Prior to the onset of clinical signs, thyroglobulin autoantibody (TGAA) becomes detectable on a blood test.

Since the majority of affected dogs will have autoantibodies by 4 years of age, annual testing for the first 4 years is recommended. The majority of dogs that develop autoantibodies have them by 3 to 4 years of age; however, after age 4, biannual retesting is recommended. A negative test at any one time will not guarantee that the dog will not develop thyroiditis. By knowing the status of the dog and the status of the dogs lineage, breeders and genetic counselors can decide which matings are most appropriate to help reduce the incidence of autoimmune thyroiditis in the offspring.

Dogs being should be examined by a veterinarian and have serum drawn and sent only to an OFA approved laboratory following the testing instructions. Dogs should not receive any type of thyroid supplementation for 3 months prior to thyroid testing. Female dogs should not be tested during an estrus cycle. It is important to use a plain red top tube without a serum barrier for sample collection. Details for sample handling and shipment are available at http://www.offa.org/thyvetinstruct.html. Under separate cover, the OFA application and appropriate fee must be submitted for certification.

Evaluation of dogs under 12 months of age can be performed for private use of the owner since few dogs are already positive at that age. However, certification will not be possible at that age. A breed database number will be issued to all dogs found to be normal at or after 12 months of age. Ages will be used in the certification process since the classification can change as the dog ages and the autoimmune disease progresses. It is recommended that reexamination occur at ages 2,3,4,6, and 8 years.

All data, whether normal or abnormal, should be submitted for purposes of completeness. There is no OFA fee for entering an abnormal evaluation of the thyroid into the data bank. Information on results determined to be positive or equivocal will not be made public without explicit written permission of the owner.

Thyroid abnormalities fall into several categories. Two types will be defined by the registry: 1. autoimmune thyroiditis and 2. idiopathically reduced thyroid function. Autoimmune thyroiditis is classified as a genetic disorder. Dogs with autoimmune thyroiditis may not be considered ideal candidates for breeding stock.

von Willebrand's blood coagulation testing

von Willebrand's disease (vWD) is the most common inherited bleeding disorder of both animals and humans. The cause is a reduction in the amount or function of von Willebrand factor (vWF), the protein necessary for normal platelet function. There are 3 forms of vWD: type I (low concentration of normally structured vWF protein); Type II (low concentration of an abnormal vWF), and Type III (complete absence of vWF). Different breeds exhibit different variations of the disease.

Most dogs, whether carriers or affected, are clinically normal. Affected dogs may present with spontaneous bleeding, usually from the mucosa of the mouth, nose, or gastro-intestinal tract. Injury that is accompanied by bleeding may require administration of a transfusion. A buccal mucosal bleeding time is an easy and quick test to perform in a suspect pre-op patient but is not a definitive diagnostic test to screen for vWD.

There are 2 screening tests currently available. The first test developed was an assay to measure the percentage of vWF protein present in an individual patient. This test was developed by Dr. Jean Dodds and is still run in the lab at Cornell University College of Veterinary Medicine. It is the only test available that will screen dogs of all breeds for vWD. Because the test measures a protein in the dynamic system of the dog's body, it is expected the result will vary from one test to the next in the same patient. Despite this variation of the absolute number of a test result, the typical patient will still be reported in the same category (normal, carrier or affected) on subsequent tests unless the patient has a change in their health status or estrous cycle from one testing date to the next. This variation has caused some confusion in the interpretation for some breeders but this should not undermine the value of the test results.

The second screening test available is a DNA test for vWD. It has been marketed as a test for multiple breeds but this author is not aware of any published reports that support the accuracy of use in breeds other than the Scottish Terrier.

Sebaceous Adenitis skin biopsies

Sebaceous Adenitis (SA) is a hereditary skin disease in which the sebaceous glands become inflammed, often leading to progressive loss of hair. SA symptoms can mimic other diseases including allergies and endocrine disorders. Some dogs affected with SA are asymptomatic. Diagnosis is based on histopathologic evaluation of skin biopsies.

The attending veterinarian examines the dog for clinical symptoms of the disease and notes any findings on the application form. A minimum of two 6mm punch biopsy samples are taken from the skin of the dog's neck between the top of the head and the withers. If there are areas of scaling and hair loss, samples should be taken from those areas.

To collect the sample, a local anesthetic such as lidocaine may be used. General anesthesia may be used as determined by the attending veterinarian. The area should not be scrubbed or otherwise cleaned, however gentle clipping of the area may be necessary. When obtaining the sample with a local anesthetic, use of a colored marker or white liquid correction fluid is helpful in finding the area with the lidocaine block. After the skin punch has removed the skin biopsy specimen, the skin should be closed with 1 to 2 absorbable sutures. The specimen should be placed in a crush proof container with formalin in preparation for shipment to the lab. The samples, the completed OFA application, and both the lab fee and OFA fee are sent only to an approved dermapathology laboratory for evaluation.

The lab results are classified as either:

- No Evidence of Sebaceous Adenitis (at the time of the evaluation)
- Affected
- Affected without Clinical Symptoms
- Equivocal (some inflammation is present, but the cause cannot be determined.

The lab results and final diagnosis are returned to the OFA and to the owner. The minimum age for registration in the OFA SA database is 12 months.

It is believed that SA is inherited as a simple autosomal recessive. There is currently no DNA test to determine a dog's status with regard to SA. As enough phenotypic information on families of dogs is entered into the database, breeders will be able to make educated assumptions about a dog's genotype. This will allow breeders to apply greater selective pressure in controlling and reducing the incidence of the disease.

Two factors make SA particularly difficult for breeders to control: the possible late onset of the disease, and the subclinical state of the disease. With late onset, the dog may have already been bred long before it ever shows clinical signs of the disease. In its subclinical state, an owner may be unaware that the animal is affected since it shows no visible signs of the disease.

OFA certificates

Some of the OFA submission forms include a line for dog owners to initial to allow the release of abnormal findings to a public database. This should be discussed with the client in advance of submission as some owners prefer to limit results to their own use.

Any questions on how to read an OFA certificate can be clarified by visiting http://www.offa.org/numberkey.html.

Genotypic screening

Tests available

Selection based on genotype – there are currently 4 types of DNA tests: parentage tests, mutation-based tests, linked marker tests, and tests to identify the breeds but not the individual parents who contributed genetics to an individual dog. DNA genetic screening is the most rapidly evolving. Although many DNA tests have been available up to now, the completion of the canine genome in 2004 and research at both commercial and non-commercial facilities is expanding the number of DNA tests available exponentially. Because tests are becoming available so quickly, it is not possible to include an all-inclusive list of DNA tests here. It is also not likely that veterinarian will be able to stay current with the available tests. Breed clubs will have recommendations regarding the tests available for screening. Careful and current research into each test should be done to be certain the test was evaluated for the breed in question prior to recommending the test. In some cases, DNA markers for one breed do not necessarily serve as the DNA marker for another breed. The laboratory selected for the analysis should be a university based laboratory, or one with an excellent reputation, have a PhD geneticist on staff and be recommended by the parent breed club.

Samples for DNA tests are usually either provided as a cheek swab on a specifically-produced cytology brush or a whole blood sample. Serum is not a suitable sample as it contains very little DNA. Frozen semen can also be used in some cases by extracting whole cells from the frozen sample. However, it is an expensive way to obtain DNA, both from the actual financial cost of sacrificing the sample and from the aspect of the loss of valuable semen which is usually limited in quantity. Each lab will have very specific sample and paperwork requirements. The most up-to-date information should be used prior to collecting and submitting the sample. A visit to the website or a phone call to the testing facility is recommended to be certain the sample and forms are the most current available as this is likely to change frequently.

General types of DNA tests available

1. Disorders of blood or blood cells: hemophilia A and B, vWD types I, II, and III, factor VII deficiency
2. Storage diseases: copper toxicosis, cystinuria, renal cystadenocarcinoma and nodular dermatofibrosis,
3. CNS and skin: Lafora type epilepsy, narcolepsy, epidermolysis bullosa (two forms)
4. Eye: Collie eye anomaly, progressive retinal atrophy/PRA
5. Drug sensitivities: malignant hyperthermia, multi drug resistence gene (MDR-1)

Parentage DNA tests

These tests have great value in determining if the pup has the parents accurately recorded with their respective registry. The only value in parentage genotypic screening applied to screening for genetic disease is for use when a DNA test used to clear a parent is used to clear offspring as genetically disease-free.

Mutation-based tests or Gene-specific tests

This is the "gold standard" DNA test. Because of accuracy of testing and shorter time needed to develop a DNA test, this test is preferred over the linked-marker test when it is available. The test identifies the actual mutated DNA that produces the defect being evaluated. Often, a canine inherited disease will be identical to a disease in human or mouse (genomes more heavily researched than the canine genome). If the mutant gene has been identified in either of these species, researchers can immediately test whether the same gene is involved in the canine disease. When it is, researchers have a very rapid route to identifying the mutations that cause inherited disease in the dog. However, it must be assessed to be the same gene in each breed of dog as in the mouse, human, or other dog breeds. On occasion, there can be different mutations that cause similar diseases in different breeds. When the scientific literature can show the defect is testing for the correct mutation in a specific breed and the parentage can be confirmed, the test is considered to be 100% accurate.

These gene-based DNA tests can be used to analyze an individual dog's DNA to determine how many copies of the mutant gene it possesses. A dog with two normal versions of the gene is classified as genetically clear; a dog with one normal version and one mutant version will be a carrier; and a dog with two mutant copies will be affected or at risk (for a disease that results from a single recessive mutation).

Examples of this type of test include progressive retinal atrophy in the Irish Setter and cystinuria in the Newfoundland. http://www.thekennelclub.org.uk/item/315.

Linkage or Linked-marker tests

With this type of test, the actual mutated DNA marker has not been identified. Instead, the test uses an identified marker that is always inherited by an affected dog but is not inherited by clinically normal dogs. Using special DNA markers developed by the Canine Genome Research project, researchers can identify unique regions along each and every canine chromosome. This co-inheritance of the DNA marker with the disease signifies that the marker is physically close to the mutant gene that causes the disease on one of the chromosomes. Here, the marker is determined to be linked to the disease gene, thus the terminology linked-marker tests. Since the markers used have all been mapped to their unique location on one or other of the chromosomes, identifying a linked marker will identify a relatively small region of just one chromosome where the mutant gene will be found. Scientists can then scan this region for potential candidate genes that can be screened for their involvement in the disease.

The presence of the linked marker is usually diagnostic for the presence of the associated mutant gene. However, linked-marker tests are rarely 100% accurate (realistically 95 to 99% accurate) because the test does not directly measure the presence or absence of the mutant gene, but rather

it's next door neighbor gene. Another cause of error using linkage testing is when a genetic marker recognizes a false allele that is not linked to the disease gene. Therefore, inaccurate diagnoses can be made if, on the rare occasion, the mutant gene and the linked marker become separated during meiosis. As technology allows, this type of test will be replaced by mutation-based tests. Be sure you or your client has checked the internet for the most current and reliable tests available prior to submission of samples.

Current examples of this type of test include renal dysplasia in the Shih Tzu and PRA in the Toy and Miniature poodle. http://www.thekennelclub.org.uk/item/315

Breed identification

Testing is available commercially to identify the breed(s) an individual dog is derived from. This will not identify specific individuals as parents, rather the breeds contributing DNA to an individual. Pet owners can submit blood samples through their veterinarian to this commercially-available service for a fee. This testing is more than a novelty; it is thought this can assist pet owners and veterinarians in identifying breed-specific traits and disorders. This test will also be of value if it is suspected an individual is not the purebred dog the breeder selling the dog represented it to be.

Use of test results

Most DNA tests currently available are tests for single gene, autosomal recessive diseases. This type of test is accurate and affordable.

These tests can distinguish between:

1. Normal (a clear dog, with two normal alleles at gene of interest)(NN).
2. Carrier (a dog with one normal allele, one disease-causing allele but without symptoms of the disorder) (Na).
3. Affected (a dog with two disease causing alleles, clinically affected or at risk of showing clinical signs) (aa).

DNA test results have many applications. First is to detect affected dogs prior to the onset of clinical signs. Second is to predict disease outcome or to prescribe treatment prior to clinical signs developing. Third is to diagnose affected dogs when they become clinically abnormal. Fourth is to detect asymptomatic carriers in the breeding population. This allows clinically normal carrier or affected dogs to be bred to clear mates, leaving these dogs in the gene pool so that their "good" genetics can be perpetuated without compounding the "bad" genetics. In doing so, genetic diversity can be maintained. In genetic diseases with complex inheritance patterns, this can be more difficult.

Counseling the breeder

While DNA testing is useful, it cannot stand alone as a diagnostic tool. Merely finding that a dog carries two abnormal genes does not prove that the dog's disorder is caused by the disease they appear to carry. For instance, a dog with two abnormal genes for degenerative myelopathy may show signs of neurologic disease, but there are other causes such as intervertebral disc disease that may produce a similar clinical picture.

For our uses, mutation-based tests and linked marker tests provide diagnostic insights. Removing all dogs who carry a genetic defect from the breeding pool is neither practical nor recommended. Our purebred dogs have been described as "endangered species" by Dr. Anne Traas. If we eliminate every dog with a defect, we will have no purebred dogs left (or any dogs left as there is no dog, purebred or mixed breed without a defect). Instead, we can apply these test results to breed phenotypically normal genotypically affected carriers to genotypically normal dogs to produce litters with small numbers of genotypically abnormal pups. The affected dogs can then be removed from the breeding pool, allowing breeders to use dogs with valuable genetics in their lines without limiting the gene pool.

There are four modes of inheritance that cause most genetic defects in dogs: simple autosomal recessive; sex-linked recessive; autosomal dominant; and polygenic.

Including a dog with a simple autosomal recessive disease into a breeding program when a genetic test is available

To produce an affected pup (aa), both parents of an affected puppy must be carriers of the abnormal gene that causes the disorder. Frequently, neither parent (both Na) will show the trait. An autosomal or simple recessive trait results when a matched pair of genes is present on any of the dog's 38 pairs of autosomes. An autosome is a non-sex chromosome.

Dogs that carry only one simple autosomal recessive gene (Na) may be used in a breeding program if matched carefully with a genetically screened (NN) mate. Even an affected dog may be included if bred to a genotypically normal dog.

First, a Punnett square should be drawn to illustrate the risks of the planned breeding to the owner.

Second, a diagram of a scientific pedigree of the dogs involved should be constructed, identifying known carriers in the pedigree. There are computer programs and articles written on how to designate male/female and normal/carrier/affected available to assist in this task. Be sure to identify both parents of affected offspring as carriers. (Standard Pedigree key: Males are identified as squares, females as circles; affecteds are colored in; carriers have a small mark through the square or circle; and clears are a clear square or circle). Identify which dogs the breeder would like to incorporate as breeding stock. Start testing with the foundation dogs as this may reduce the number of tests necessary. If all foundation dogs are clear and there is not a recent mutation, no additional tests are necessary. If affected and carrier dogs are found, testing of offspring is necessary.

Third, if indicated, test all potential sires and dams. If only normal/clear (NN) dogs are mated, no affected dog will be produced. When an x-linked gene carried by an (unaffected) male is bred to a clear female, all offspring from this mating must be tested to assess their carrier (male or female) or affected (female) status. When an affected male is bred to a clear female, ALL offspring must be carriers and need not be tested.

Fourth, if any carrier (Na) is included in the breeding, offspring may be tested as very young pups to detect carrier (Na)/affected (aa) status prior to placing pups in homes.

If an affected dog (aa) is to be included as a breeding dog, the breeder should be counseled that the dog must be outstanding in many other ways to merit this. This may include temperament, performance, and physical traits but this should be in line with objective goals established for their breeding program. The disadvantage to including this dog as a breeding dog is it will quickly increase the incidence of the mutant allele (Na) in this population. By design, all offspring of the affected dog will be carriers (Na) and need not be tested (or affected (aa) if the gene is carried by both parents – this is NOT advised). In future generations, the affected (aa) breeding stock can be replaced with their offspring that are clear (NN) or carriers (Na) with outstanding qualities. These carriers (Na) can be replaced by adding new animals to the line that have been tested.

Used correctly, these DNA results will allow veterinarians and breeders to select potential breeders with greater insight.

With all of these test findings available to the breeder, the breeder may look to the veterinarian for input on how to interpret the data and how to put it to use in their breeding program. This is a great challenge for us as veterinarians. There is no genetically perfect dog, whether purebred or hybrid; they all have at least one genotypic or phenotypic defect. Our goal as consultants to our breeder clients is to assist them in making the best genetic choices they can.

Option #1
2 NORMAL PARENTS (NN) → 100% NORMAL OFFSPRING

PARENTS	N	N
N	NN (normal)	NN (normal)
N	NN (normal)	NN (normal)

Option #2
1 normal (NN) and 1 affected (aa) parent = 100% carrier OFFSPRING but 0 affected pups

PARENTS	N	N
a	Na (carrier)	Na (carrier)
a	Na (carrier)	Na (carrier)

Option #3
Both carrier parents (Na) → 25% normal and 50% carrier and 25% affected OFFSPRING

PARENTS	N	a
N	NN (normal)	Na (carrier)
a	Na (carrier)	aa (affected)

Option #4
1 carrier parents (Na) x 1 affected (aa) parent → 50% carrier and 50% affected OFFSPRING (Not recommended)

PARENTS	N	a
a	Na (carrier)	aa (affected)
a	Na (carrier)	aa (affected)

Option #5
Both affected parents (aa) → 100% affected OFFSPRING (Not recommended)

PARENTS	a	a
a	aa (affected)	aa (affected)
a	aa (affected)	aa (affected)

Use of this visual tool with help veterinarians and breeders alike make better decisions on who to include and exclude, or who to combine genetically for breeding when breeding dogs with known traits with known genetic tests when an autosomal recessive gene is believed to be involved.

Incorporating a dog with a simple autosomal recessive disease into a breeding program when a genetic test is NOT available

Known carrier dogs should not be used for breeding. We can only counsel clients by using phenotypic tests – traits visible on examination or by testing using specific criteria. Then we can advise the client using probabilities of inheritance.

Counseling for X-linked recessive diseases

Sex-linked genes can be either dominant or recessive and always appear on the X-chromosome, making the female the carrier. By definition, males cannot be carriers (they have no X chromosome), only affected or normal. In the male, as he has only one X chromosome, the single recessive gene that is part of that chromosome expresses itself, expressing the trait that requires two genes to be expressed in the female. The mothers of all affected males must be either a carrier or affected; they

are never normal. Females can only be affected if their fathers are affected AND their mothers are carriers or affecteds. Only females must be tested for carrier status.

If these dogs are identified early, the disorder can be eliminated before they enter the gene pool of their breed.

An example of an x-linked recessive disease is Ectodermal Dysplasia found in German Shepherds and Border Collies.

Counseling for autosomal dominant diseases

An autosomal dominant trait results when a trait is expressed without a pair of matching genes. Only one parent must have the defective gene for the disorder to cause the trait to occur in the offspring.

This type of disorder is easy to eliminate from the gene pool if the onset is early in life, as it is obvious this dog is not a candidate to join the gene pool. However, if the onset is later in life, the dog or bitch has often already been bred. Typically, only one parent carries the genetics for this type of disorder. It may be necessary to test both parents, but it is reasonable to test one at a time to save money. If a DNA test is available, affected animals should be de-sexed and never included in the gene pool. If a DNA test is unavailable, affected dogs should be de-sexed. If the onset is later in life and there is no DNA test available, dogs with the potential of being affected should NOT be used for breeding until they are past the age of onset. For quality male dogs, semen can be frozen while they are young and reserved for use until they are past the age of onset of the disorder to improve the likelihood they are clear before breeding.

If this type of disorder is found to be a new mutation in the germ line, the mutation may appear for the first time in this generation with neither parent affected. It may be possible to have more than one affected offspring in this generation.

Examples of these diseases are Severe Combined Immuno-deficency (SCID) in Pembroke and Cardigan Welsh Corgis, Ehlers-Danlos Collagen deficiency, and dominant PRA in Mastiffs and Bull Mastiffs.

Decision-making on inclusion in a breeding program is more difficult when a large percentage of a breed population is affected by an autosomal dominant disease. Elimination of all affected dogs will allow a faster decrease in the number of affected puppies produced. However, the trade-off is a loss of genetic diversity in the line, leading to 2 outcomes. One is the chance of uncovering or increasing the incidence of another genetic disease due to increased inbreeding coefficients. The other is the loss of other desirable traits, limiting the opportunities in future generations to maintain or improve the breed in future generations.

The alternative to elimination of all affected breeding dogs is to continue to breed affected dogs. Even if an affected dog is bred to an affected bitch, statistically only 50% of their offspring will be affected. The dilemma is how the breeder is to manage finding homes for affected puppies. The breeder would then be counseled to continue to breed affected animals replacing them with the best quality offspring. Once a DNA test becomes available, testing can be applied to determine which dogs should be maintained in the breeding pool.

Genetic counseling for diseases with suspected genetic basis or multiple gene inheritance

Polygenic traits or complex traits are controlled by multiple genes, each of which adds incrementally to the total phenotype.

There are many diseases suspected to be inherited but either the inheritance pattern has not been established or it is suspected this is inherited on multiple genes. These include hip dysplasia, many forms of cancer, allergies, gastric dilatation and volvulus, and immune-mediated diseases.

Even without DNA tests, progress to reduce the incidence in a population is possible. Using results from OFA or PennHIP® and analyzing not only the results of the proposed breeding pair but also including the information from the grandparents and siblings of the parents, it is possible to lower the incidence of the disorder. It must be remembered to factor the other traits of the dogs to be mated into the decision and not to breed for one trait alone.

The future of DNA testing

Progress in DNA profiling has made testing for genetic disorders a rapidly evolving process. Fortunately, internet research allows us to keep up with the advances. A search by dog breed allows us access to current information on tests available. A search by laboratory will provide testing information to the veterinarians – what samples to collect, how to submit them, the fees, and how and where to ship the samples.

It is possible now to offer DNA banking services, either in your own practice or by referring breeders to a company which provides this service. By banking DNA, clients can access the DNA of dogs and bitches important to their breeding program later and evaluate these dogs as new DNA tests become available in the future.

Soon, tests for polygenetic diseases and DNA profiles including thousands of genes will become available. Using DNA profiles and computer programs, we will not only be able to calculate the probability of individual offspring inheriting desirable or undesirable traits, but we will also be able to predict the effect of changing one or several gene frequencies in a dog population over time. As new mutations arise, they have the potential to be singled out and eliminated from the gene pool efficiently. Until recently, many breeders were advised to "outcross" a dog with an unknown defect. "Instead of controlling a trait when there are one or two dogs, or one or two families involved, we outcross the dogs and spread the trait throughout the breed." "This advice has messed up breeds of dogs from the beginning of time," Padgett says. By doing so, instead of diluting the genetic defect out, they inadvertently spread it throughout their breed, infiltrating many pedigrees with this new mutation. (George Padgett, D.V.M., former professor of pathology at Michigan State.)

The power of this genetic manipulation has yet to be seen. There is great potential to improve the health, appearance, and behavior of an entire population. However, if we err, there is great potential for causing harm. Until we understand this power more thoroughly, we must take great care in how we advise clients.

Line breeding

There are two broad categories of mating schemes: inbreeding and outbreeding (or outcrossing). To some degree, mating any two dogs of the same breed is inbreeding. Mating closely related animals is classified as inbreeding – this includes breeding parent to offspring, or breeding full brother to full sister. Here, the breeding coefficient is 50%. Mating less closely related animals together is outbreeding. There is disagreement on how distant a relationship between the two animals needs to be to classify it as an outbreeding. Line breeding is the term used when individuals to be bred have one or more common ancestors on one or both sides (sire or dam's side) of the pedigree in the last five generations. Computer programs have been developed to calculate the breeding coefficient.

Line-breeding is a technique used in many species by breeders. Although not a new technique, it became well-known in dogs when popularized by Lloyd Brackett, a German Shepherd dog breeder in the 1950's. It is most commonly used to produce a group of individuals with similar characteristics, dogs homozygous for a hopefully desired similar characteristic. The desired outcome is to produce a uniform quality of offspring. To produce consistent quality, this generally requires line-breeding for several generations. The advantage of line breeding, especially of having the same dog on both the sire and dams side of the pedigree, is that genes can then pair up and produce a more uniform litter

than when an outcross breeding is done. With careful analysis, many breeders have produced quality offspring when breeding siblings to one another or breeding a female back to her father's father. If the breeding co-efficient becomes too high, the breeder may then look to a less closely related dog and breed to produce an "outcrossed" litter.

The disadvantage of line breeding is, at times, it can uncover or magnify traits that were not foreseen. Inbreeding does not cause a mutation that results in an inherited disease, but once such a mutation has occurred, inbreeding will increase the frequency of the mutant version of the gene in the breed more quickly than other more random breeding programs. Until all genetic diseases have a phenotypic or genotypic test available, there is a degree of risk when line-breeding. To effectively and safely line breed a litter, the breeder must be very familiar with individuals in the preceding five generations. Therefore line breeding is not recommended for the breeder who is not experienced or the weak-at-heart breeder. Should a line breeding lead to an unexpected and unfortunate outcome, difficult decisions may need to be made pertaining to the future of the offspring produced.

Line breeding may be necessary to perpetuate a breed with a very small gene pool. AKC records show that in 2002, there were 44 breeds with fewer than 100 pups produced each year for 5 consecutive years (1997 to 2002).

Most experienced breeders will use some degree of line-breeding to produce consistent appearing or consistent performing dogs.

"Founders effect" or "Matador"

At times, a stud dog is used so frequently he can have a disproportionate effect on the gene pool of a breed. This phenomenon, known as "founder's effect" or the sire known as a "matador", can cause the loss of genetic diversity. The concern is that he not only has a positive influence on the breed, but that he can concentrate undesirable traits in the breed. To minimize this possibility, some people have suggested a stud dog should not sire more pups in his lifetime than a bitch could produce.

The advantage of breeding to a frequently used stud dog is that a great deal is known about the offspring he produces. If a stud dog has been used heavily and has produced few pups with undesirable traits, this dog is likely to be more valuable to include in a breeding program than a unknown or unused stud dog with no track record of what they produce.

Figure 2-6.
At a puppy party, the breeder has an opportunity to assess offspring for breed type, soundness, temperament, and overall what their breeding program is producing.

The breeding program

A great challenge, but great tool, in selecting dogs to be used in a breeding program is to follow the pups produced for their lifetime. Encourage your breeder clients to do the following:

Have "puppy parties" where the pups they have bred have reunions. At these events, have someone (not the breeder) videotape the dogs in attendance. With this method, the breeder can speak to the owners of the pups to learn of health histories, temperaments, and accomplishments, and later view video showing their conformation, movement, and behavior (Figure 2-6).

On a weekly to yearly basis, suggest the breeder write, e mail or call owners of their pups just to stay in touch. Christmas cards with photos from puppies sold to families can be an invaluable source of information to the breeder.

Arrange to have the offspring's hips (and other joints as indicated) radiographed and have eyes examined, as well as have other screening tests done as dictated by the prevalence of disorders in the breed. Arrangements may be made to do them as a group if the pups live in close proximity to the breeder, when a group discount may be negotiated. OFA offers a significantly reduced fee to read films when they are submitted (not taken) together. This will provide valuable data to the breeder. Some breeders provide a financial incentive such as a reimbursement if the pet owner has these tests or examinations completed. This is usually a fee included in the purchase price of the dog, and terms of the reimbursement and testing required are written into the contract at the time of purchase. It is not enough to know the results of the tests from only the dogs kept by the breeder. Dogs sold as "pets" should be included in the analysis by the breeder to permit a comprehensive assessment of the breeding program.

The perfect dog

Should you use this dog or bitch in your breeding program?

There is no perfect dog! All dogs in breeding programs carry one or more undesirable traits. Yet, to prevent extinction of the breeds we know today, some of these dogs need to be included as breeding stock.

It is critical to recall that dog and cat breeds are closed populations with no new genetics available. Of course, the goal of breeders is to plan matings to avoid the "production" of an affected dog. However, selection based upon only one trait will limit genetic diversity and ultimately will be detrimental to a breeding program. Therefore, harsh elimination of individuals from a breeding pool must be avoided and should not be recommended without discussion of the pros and cons. Instead, with careful selection, carriers can be bred to other carriers or clears, the offspring tested and breeding stock can be replaced with clears.

Summary for counseling clients in genetic selection

1. Do not breed affected dogs unless they carry only a mild or curable disorder. Examples are umbilical hernias and disticihia.
2. Screen all breeding stock for as many disorders as is feasible, based on the tests available and the associated costs.
3. Breed clear to clear whenever possible.
4. Breed clear to carrier when there is a 30% or less incidence of disorder or if this is otherwise a very desirable dog.
5. Test all offspring, not just breeding stock.
6. Select clear in next generation.
7. Do not select only against one disease as this ignores other diseases and will limit the gene pool.

There are many highly qualified breeders who are skilled at evaluating pedigrees and genetic testing, then applying it to develop breeding plans. However, as veterinarians, we must continue to offer this counseling service to our clients or aid them in locating a qualified geneticist to advise them in planning their breeding programs. If we fail to provide this testing and fail to advise our clients on how to use genotype and phenotype results, they will rely on others who may be less able to assist them in collecting data, interpreting test results and applying it to their breeding program. The power of genetic insight has yet to be realized. Used inappropriately, we could do great harm to the genetic diversity of the canine population. Used well, we have great potential to improve the health of the canine population. Our clients depend on us to help them make ethical and scientifically-based decisions. Understanding the basics of genetic selection is an invaluable service we can provide to breeder-clients.

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