

# Dog Disease Research

at the Broad Institute



Winter 2014

## The Broad marks a banner year in furthering our understanding of dog disease genetics

– thanks to committed dog owners like you and our other partners. Your generous donations of biological samples, research funds, and health updates have contributed greatly to unraveling clues to disease in the dog genome over the past year. With your help, we now have nearly 17,000 samples from more than 150 different breeds to support our research. The following is just a snapshot of what your generosity has helped us achieve this past year. Thank you for being a committed partner in our work.



## 2 Million Dogs Gift Funds Mast Cell Tumor Research

This year, Trooper, a St. Bernard, won the top spot for the 2 Million Dogs Foundation's annual calendar contest showcasing survivors of canine cancer. But the Broad Institute's dog disease research group may be the biggest winner for the second year in a row.

For the past six years, 2 Million Dogs has donated money generated from its "Cancer Can't Keep a Good Dog Down" calendar contest to fund cancer research studies in dogs. Following the 2014 contest, the foundation awarded the Broad \$20,000 to study canine mast cell tumors—an aggressive cancer which accounts for almost one third of all skin tumors in dogs. The disease is closely related to mastocytosis, a painful skin condition in humans. It was the second year that the Broad was picked as the primary funding recipient by 2 Million Dogs' board of directors. In 2012, they donated the proceeds from the calendar to the Institute's osteosarcoma research in dogs. "The Broad's technology and infrastructure are

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Broad scientists have found a gene that raises the risk of atopic dermatitis in German Shepherds.

#### Guiding Eyes for the Blind Donates to Mast Cell Tumor Research

It's vital that researchers help breeders reduce the likelihood of inherited diseases among these working dogs.

#### International Conference on Advances in Genomics and Inherited Diseases

For a week this past September, the Broad Institute hosted the 7th Canine and Feline Genomics and Inherited Diseases.

#### Q&A with Broad Research on Kidney Disease in Dogs

Like many of the Broad's associate researchers, Andrew Lundquist, M.D., Ph.D., divides his time between research and hands-on clinical care.

#### Leonberger Health Foundation: Supporting Canine Cancer Research

Founded 13 years ago to improve the lives of Leonbergers, the Leonberger Health Foundation has been an important partner to the Broad Institute's dog disease research group.

#### Researchers Identify 33 Risk Factors for Osteosarcoma

Scientists have uncovered dozens of genetic risk factors associated with osteosarcoma, an aggressive type of bone cancer.

#### Mutation in Chromosome 13 in Shar-Pei Dogs

A common genetic risk factor that predisposes Shar-Pei dogs to a spectrum of persistent inflammatory symptoms that affect the skin, joints, ears and body as a whole—revealed.

#### Genetic Adaptations to Starch-Rich Diet Provide Clues to Dog Domestication

This evolutionary adaption may be one of the crucial steps in the dog's survival—and success—among human populations.

## 2 Million Dogs Gift, cont'd.

top-notch, state-of-the-art," explained Luke Robinson, founder of 2 Million Dogs. "We decided to fund a second study because of the impressive work they are doing in genomics research."

Because of the high-incidence of mast cell cancer in dogs, the canine genome offers a unique opportunity to understand the biology of the disease. "By looking for genetic risk factors in multiple dog breeds we will be able to learn what disease mechanisms underlie mast cell tumor, a devastating disease," said Kerstin Lindblad-Toh, scientific director of Vertebrate Genome Biology at the Broad Institute who oversees the Institute's dog disease-mapping group. Work on this project is already underway and will now be expanded, thanks to 2 Million Dogs.

Research into canine mast cell cancers doesn't just benefit dogs. "Determining the underlying genetics for canine cancers like mast cell will lead to better diagnostics, prevention and treatment of both canine and human disease," Lindblad-Toh said.

Indeed, the Broad's unique approach of studying the disease in both species was a draw for 2 Million Dogs, which is committed to discovering the common links between canine and human cancers. "Cancer is a cross-species disease," Robinson noted. "Because of that, it is fascinating to work with the Broad Institute which does research from a multi-species perspective."

## Guiding Eyes for the Blind Donates to Mast Cell Tumor Research



Dogs are more than just pets and companions—many also help us as guide and service animals. So it's vital that researchers help breeders reduce the likelihood of inherited diseases among these working dogs. In July, Guiding Eyes for the Blind, Inc. donated \$20,000 to the Broad Institute toward the identification of genetic risk factors of mast cell tumors—a common form of skin cancer—in their dogs.

A leading school in training dogs for the visually impaired and service dogs for autistic children, Guiding Eyes maintains an extensive database to monitor the health of its dogs.

If a problem emerges, the school uses the data to determine to what extent genes play a factor and then employs quantitative genetics tools called Estimated Breeding Values (EBVs) to help guide breeding. Guiding Eyes has successfully used EBVs to reduce inherited diseases such as hip dysplasia, elbow dysplasia and epilepsy among their Labrador Retrievers.

"With the use of EBVs, the incidence of mast cell tumor declined. However we wanted to pursue the possibility of making even faster progress by supporting research to identify markers or if possible, the



## Study Finds a Gene Associated with Atopic Dermatitis in the German Shepherd

Broad scientists have found a gene that raises the risk of atopic dermatitis in German Shepherds. Atopic dermatitis is on the rise in both humans and dogs, and this latest discovery could lead to insights into the skin condition among human patients.

German Shepherds have a higher prevalence of atopic dermatitis than other breeds. In a paper published last May in *PLoS Genetics*, the dog disease research group reported on a genome-wide association study in the breed identifying a gene locus associated with atopic dermatitis. "There are a total of eight genes in this locus and our research suggests that the association between atopic dermatitis in this breed is associated with one of these genes called *PKP2* which is located on chromosome 27," explained Katarina Tengvall, one of the study's authors.

*PKP2* produces the protein Plakophilin 2, which is known to be important for skin structure. "It may be that this gene is somehow defective or the protein functionally makes the skin is more fragile," Tengvall said.

Though this genetic risk factor alone does not explain everything about atopic dermatitis in German Shepherds, it will likely help identify part of its cause and development. Factors such as environmental and other genetic influences also play a role.

Tengvall said Broad researchers are now conducting studies to learn if and how the *PKP2* gene is defective in affected dogs. They are also collecting samples from other breeds and studying environmental data to identify specific risk factors in different breeds.

To continue the study, Tengvall appealed to dog owners for more samples from their pets. "We are looking at expression in the skin tissue itself," she explained. The collection of data from affected dogs as well as controls will help the scientists conduct more whole genome-wide studies in other breeds and also strengthen their analysis in the German Shepherd. "Atopic dermatitis is such a similar disease in humans that we hope to find useful information that will help our understanding of its causes in dogs and humans as well," Tengvall said.

*Katarina Tengvall, Marcin Kierczak, Kerstin Bergvall, Mia Olsson, Marcel Frankowiack, Fabiana H. G. Farias, Gerli Pielberg, Örjan Carlborg, Tosso Leeb, Göran Andersson, Lennart Hammarström, Åke Hedhammar, Kerstin Lindblad-Toh*

**"Genome-Wide Analysis in German Shepherd Dogs Reveals Association of a Locus on CFA 27 with Atopic Dermatitis." *PLoS Genetics* 10.1371/journal.en.1003475**

## Guiding Eyes, cont'd.

gene[s] responsible for mast cell tumor, hopefully resulting in a genetic test," said Jane Russenberger, senior director of Genetics and Canine Development at Guiding Eyes. "Identifying Broad Institute as the recipient of our gift was an obvious choice because of Broad's reputation for excellence in the field of molecular genetics, their collaboration and sharing of knowledge with others and our shared vision for research in field of cancer."

So far, a mast cell genome-wide association study has identified three regions in the genome of Guiding Eyes pedigree dogs associated with mast cell tumors. The dog disease research group at the Institute now plans to sequence the genome of the diagnosed cases and healthy controls to identify causal variants. The hope is to confirm these in a larger cohort and evaluate their use for predicting the risk of the disease. Guiding Eyes plans to use any genetic testing from this research with its breeding dogs as quickly as possible.

With this gift, the Broad aims to help Guiding Eyes meet one of its long-term goals—to improve canine health by developing better diagnostic tools to inform breeders.



## Broad Institute Hosts Conference on Advances in Canine and Feline Genomics and Inherited Diseases

For a week this past September, the Broad Institute hosted the 7th Canine and Feline Genomics and Inherited Diseases. This meeting alternates between the United States and Europe on a biannual schedule. Lindblad-Toh has been on the Scientific Organizing Committee for many years and last year she and colleagues hosted the meeting in Sweden. It was such a success that the Scientific Organizing Committee and our kind sponsor Nestle Purina asked Lindblad-Toh to host the meeting again — this time at the Broad Institute. Hosting it at the Broad Institute this year was especially timely as the canine genome was sequenced at the Broad Institute exactly 10 years ago.

Eric Lander, the president and director of the Broad Institute, delivered one of the keynote addresses at the weeklong conference, describing the critical relationship between research in canine genetics and study in human genetics. Another keynote was given by Gustavo Aquirre, a professor of medical genetics and ophthalmology at the University of Pennsylvania School of Veterinary Medicine, on the treatment of genetic eye diseases.

Scientific presentations from dog disease researchers at the Broad and its partner, Uppsala University in Sweden, included Elinor Karlsson's presentation of encouraging findings from a genome-wide association study implicating 33 loci in inherited osteosarcoma in dogs.

Hyun Ji Noh discussed a comparative approach to identifying genetics in cases of dog and human obsessive-compulsive disorder. Noriko Tonomura's talk focused on the interaction between the immune system and malignant cells in tumorigenesis for two cancers in golden retrievers.

Maja Arent presented her genome-wide association study of canine mast cell tumors in two populations of golden retrievers, which pointed to a common pathway. Finally, Katarina Tengvall discussed her study on atopic dermatitis in German Shepherd dogs. (For more details, see the article under Scientific Stories.)

The conference was also an opportunity to bring together researchers, paving the way for future collaborations and new directions in research. Broad scientists also shared novel genome annotation and exome resources during a workshop.

## Leonberger Health Foundation Donation: Nearly 10 Years of Supporting Canine Research



In 2013, the Broad Institute's dog disease research group was honored to be a recipient of a generous \$20,000 donation from the Leonberger Health Foundation (LHF) for ongoing research into osteosarcoma, an aggressive bone cancer that affects large-breed dogs at a rate 10 times higher than other breeds. Since 2004, the LHF has been an important partner in the Broad's work on osteosarcoma and hemangiosarcoma, with gifts totaling more than \$90,000.

The LHF was founded 13 years ago by the late Waltraut Zieher with the mission of improving the lives of the Leonberger, a large working breed from Germany. Waltraut, who also founded the Leonberger Club of America's Health, Education, and Research committee, passed away from cancer in 2012, but she inspired many others to continue her work. "Osteosarcoma and hemangiosarcoma are the most tragic and predominate killers of our dogs," said Caroline Bliss-Isberg, vice president of the LHF. "Hardly a month goes by without someone posting on our online discussion and social networking sites the tragedy of a new diagnosis and pleas for help making in the awful decisions about amputation and chemotherapy."

Waltraut discovered Kerstin

## Q&A with Broad Researcher on Kidney Disease



Like many of the Broad's associate researchers, Andrew Lundquist, M.D., Ph.D., divides his time between research and hands-on clinical care. Lundquist, however, takes it to another level— he studies inherited kidney disease in dogs as well as humans. As a nephrologist at Massachusetts General Hospital (MGH), his specialty is treating patients with inherited kidney disorders like poly-cystic kidney disease, dysplastic kidney disease, and Fabre disease. He joined the Broad's dog disease research group nearly three years ago to

perform genetic studies in dogs with inherited kidney disease.

### **Why did you choose to specialize in kidney disorders?**

**AL:** I like physics, medicine, and thinking about the whole body. The kidney is responsible for clearing electrolytes, salts, and toxins. When the kidneys don't work well it affects the whole body so you have to be able to think about the heart, brain, the GI tract ... to take in the whole picture. Clinical care covers a pretty wide breadth. You take care of patients in the ICU, clinic, perform kidney biopsies transplants, and dialysis. There is always something to challenge you.

### **Why did you start working on the genetics of kidney disease in dogs?**

**AL:** Most of the patients with inherited kidney disease at MGH are followed in my clinic. I was doing research one day and noticed that a number of dog breeds also get inherited kidney diseases. I thought that would be an interesting system to study and that we could potentially help both humans and dogs by studying naturally occurring kidney disease that is known to be genetic. Then I noticed that Kerstin Lindblad-Toh at the Broad was working on the same thing so we talked about various projects and got started.

### **What is your current research focus?**

**AL:** I've started working on canine juvenile renal dysplasia, a disease in which the kidneys do not differentiate properly into the adult type kidney. In humans, this disease is called hypodysplasia. We know a lot about it in people—it's the second most common cause of kidney disease in children so it is pretty well-studied.

JRD typically affects younger dogs, less than four or five years old. Eventually the dogs die from the dysfunctional kidneys. It affects most breeds, but some breeds appear to have a high predilection like Boxers, Lhasa Apso, and Shih Tzu. If we knew more about the genetics of JRD we might be able to identify which dogs would be susceptible and potentially even guide breeders.

We initially focused on Boxers because that is what we have the most samples from. But we are also collecting samples from as many breeds and as many affected dogs as possible.

### **What have you discovered so far?**

**AL:** From samples of U.S. Boxers, we found a region that seems associated

## Leonberger, cont'd.

Lindblad-Toh's work with the canine genome and osteosarcoma. "Kerstin has been a steadfast friend to our breed for almost a decade, tirelessly giving us tours, providing workshops at our national specialty shows and answering endless questions," said Bliss-Isberg. "Many of us, especially our two LHF board members who are veterinarians, follow her research closely and read articles coauthored and authored by her."

Just this past year, Broad scientists presented compelling new findings related to the genetics of osteosarcoma. A genome-wide association study on three separate large-breed dogs implicates 33 genetic areas in heritable dog osteosarcoma. One gene in particular may also be associated with osteosarcoma in the Leonberger.

The Broad is proud to support the mission of the Leonberger Health Foundation and grateful for its steadfast generosity.



## Q&A, cont'd.

with renal dysplasia. We are trying to find the mutation that causes JRD in Boxers.

### What is most challenging about your dog research?

**AL:** The tools to move quickly with genetic studies in dogs lag a little behind that which exists for humans. In humans, we can do genetic studies because we've sequenced thousands of humans and have lots of data from normal as well as affected individuals. It is much easier to identify something novel if you have a database of thousands of normal samples.

But in dogs we aren't there yet. More funding and more studies and more samples are needed in order to have the genetic data to tell if something you've identified may be new or if it is normal, but no one else has seen it before.

### What types of samples do you need most?

**AL:** We need many more samples from dogs with renal dysplasia, both from Boxers and other breeds. But we are interested in any dog with kidney abnormalities because we're trying to build a database to look at kidney disease of all types.

### What has surprised you most since joining the dog research group at Broad?

**AL:** I have been so impressed by the involvement of the owners of the dogs. They are very persistent and caring of their dogs, more so than humans for themselves sometimes.

### What is the most interesting part of your work with the dogs?

**AL:** The fact that similar disease states can affect different species in a similar way and using that information from one species to inform the others. It is very exciting when you think you've made a discovery in either dogs or humans and go the other direction to learn more about the other species.

### What might surprise someone to know about kidney disease—either in dogs or humans?

**AL:** Kidney disease is silent for a relatively long period of time. You can have only about 15 to 20 percent kidney function remaining and not notice significant symptoms. But once the disease gets to that point, it often progresses pretty quickly.

### What are your future goals for your dog research?

**AL:** We'd like to establish a foothold in canine kidney disease here at the Broad. Dogs have many other kidney diseases aside from renal dysplasia that have a human equivalent. We'd like to be known as a group that is interested in kidney disease in the dog so we can collect many, many samples from a variety of breeds with kidney disease.

Research—both in humans and dogs—requires sufficient samples and it takes a long time, sometimes years, to get reliable results. We need tens if not hundreds of samples to reliably compare normal to disease state—and to have the confidence we've identified an answer. Small-scale studies sometimes identify a link, but the link may not hold true in the bigger picture. But you can't know this until you look at a large number of subjects.

## Researchers Identify 33 Risk Factors for Osteosarcoma

Scientists have uncovered dozens of genetic risk factors associated with osteosarcoma, an aggressive type of bone cancer that is common among several large dog breeds. The findings could have implications for the disease in humans.

In people, the disease is rare and primarily affects teenagers, but otherwise osteosarcoma in humans and dogs is very similar.

The Broad Institute and its collaborators have been studying osteosarcoma for a long time by comparing the genomes of sick and healthy dogs from three different breeds and looking for inherited risk factors for the disease. The results of the study were published in *Genome Biology* in December.

"We find 33 genetic risk factors, very few of which are shared across the breeds. Our results explain much of the increased risk for these breeds," said Elinor Karlsson, the lead author of the study who developed many of the new analytical tools necessary for this large study.

Intriguingly, each breed has its own risk genes, but these genes converge in common disease mechanisms. Some genes are known cancer genes in humans, while others are completely new discoveries. The researchers also studied one of the risk factors in more detail and found a new regulatory signal that leads to increased gene expression in bone cancer cells from humans.

"Our results show that the pathways involved in bone formation and growth are important for the disease. Because of the great similarities between bone cancer in dogs and humans, we believe that our findings may contribute to an increased understanding of how bone cancer develops in humans," said Karlsson. The Broad researchers are continuing to study the identified risk

## Obsessive-Compulsive Disorder in Dogs and Humans

Researchers at the Broad Institute are collaborating closely with thousands of dog owners on uncovering the genetic underpinnings of canine obsessive-compulsive disorder. This past October, Elinor Karlsson, an associate scientist at the Broad, delivered a fascinating lecture on efforts to determine the genetic causes of OCD in dogs, and the implications for therapies in humans.

You can watch her lecture by logging onto: [broadinstitute.org/canineocd](http://broadinstitute.org/canineocd)

## Mutation in Chromosome 13 in Shar-Pei Dogs Linked with AutoInflammatory Disease Syndrome



A study by Broad researchers and their colleagues in Sweden revealed a common genetic risk factor that predisposes Shar-Pei dogs to a spectrum of persistent inflammatory symptoms that affect the skin, joints, ears and body as a whole.

In a paper published in October, scientists from the dog disease research group at Uppsala University and the Broad showed that Shar-Pei breed is predisposed to Shar-Pei Autoinflammatory Disease (SPAID) by studying the genetics underlying its manifestations. A 2011 paper by the same team of researchers demonstrated that a genetic mutation that causes the thickened and wrinkled skin

of Shar-Pei dogs is also linked to periodic fever disorder.

In the recent study, researchers used separate genome-wide analyses to investigate five signs of SPAID—recurrent fever, arthritis, breed specific secondary dermatitis, otitis, and systemic reactive amyloidosis. The research showed that each trait was located in the same region on Chromosome 13, implicating a shared genetic risk factor for all signs of inflammation or more specifically, a single genetic locus for SPAID.

Treating each trait as a single entity was one of the strengths of the analysis. The researchers realized early on that SPAID was a complicated disease with numerous symptoms, but were truly excited to find a second genomic region on chromosome 14 which was only associated with amyloidosis. In particular, four genes on chromosome 14 previously known to have a role in kidney and immune health — *AOAH*, *ELMO1*, *HAS2* and *IL6*—are implicated in amyloidosis.

“This signal was masked when we combined all the inflammatory signs in one analysis,” explained Jennifer Meadows, one of the study’s authors. The study underscored the complexity of inflammatory syndromes where a key disease contributor gives rise to many different symptoms. “Yet the study also shows how, by looking at individual symptoms, we can find additional

## 33 Risk Factors, cont’d.

factors to further understand how they affect tumor development and to see whether different risk factors respond to different types of treatment. In addition, they are expanding the study to include more breeds.

“We are excited to continue our work on understanding osteosarcoma and to take our results towards better diagnosis and treatment strategies,” said Kerstin Lindblad-Toh, who leads the Broad’s dog disease research group.

Karlsson EK, Sigurdsson S, Ivansson E, Thomas R, Elvers I, Wright J, Howald C, Tonomura N, Perloski M, Swoford R, Biagi T, Fryc S, Anderson N, Courta-Cahen C, Youell L, Ricketts SL, Mandlebaum S, Rivera P, von Euler H, Kisseberth WC, London CA, Lander ES, Couto G, Comstock K, Starkey MP, Modiano JF, Breen M, Lindblad-Toh K.

**“Genome-wide analyses implicate 33 loci in heritable dog osteosarcoma, including regulatory variants near *CDKN2A/B*.” *Genome Biol.* 2013 Dec 12;14(12):R132.**

## Mutation in Chromosome 13, cont'd.

risk factors contributing to those particular aspects of disease," said Kerstin Lindblad-Toh, the leader of the dog disease research group. The separate components of disease will be very important also for human inflammatory syndromes."

Mia Olsson, Linda Tintle, Marcin Kierczak, Michele Perloski, Noriko Tonomura, Andrew Lundquist, Eva Murén, Max Fels, Katarina Tengvall, Gerli Pielberg, Caroline Dufaure de Citres, Laetitia Dorso, Jérôme Abadie, Jeanette Hanson, Anne Thomas, Peter Leegwater, Åke Hedhammar, Kerstin Lindblad-Toh, Jennifer R. S. Meadows (2013) "Thorough Investigation of a Canine Autoinflammatory Disease (AID) Confirms One Main Risk Locus and Suggests a Modifier Locus for Amyloidosis." *PLoS ONE* 8(10): e75242. doi:10.1371/journal.pone.0075242

## Genetic Adaptations to Starch-Rich Diet Provide Clues to Dog Domestication

New genetic research sheds light on how dogs might have thrived among humans. Unlike wolves, their close relatives who are exclusively carnivorous, dogs can digest starches, a metabolic feat that allows them to absorb energy from starch-rich foods. This evolutionary adaptation may be one of the crucial steps in the dog's survival—and success—among human populations.

In a paper published in January in *Nature*, scientists from the dog disease research group describe the results of examining the full genomes of dogs and wolves to hone in on regions that separate the two species. "We compared pooled DNA from 60 dogs from 15 different breeds with a pool of DNA from 12 wild dogs," explained Eric Axelsson, one of the study's authors. Across most of the genomes, dogs and wolves were similar, but some regions showed striking differences. Researchers took a closer look at those regions, uncovering some surprising discoveries. "That is when we noticed that there are several genes having to do with digestion, and in particular digestion of starch. That is the genomic signature of dog domestication," said Axelsson.

The *Nature* paper discussed how this crucial adaptation helped dogs thrive among humans. As humans abandoned a nomadic lifestyle in favor of agriculture and settlement, they left behind more garbage. Animals that could scavenge and digest food scraps were better equipped for survival.

Altogether, the researchers focused on 36 regions that likely represent targets of selection during domestication. Half of these regions harbor genes tied to brain development or signal processing that occurs in the brain. The researchers also identified 10 genes in other genetic regions that play key roles in the digestion and metabolism of starches and fats. The team is continuing to study the genes tied to the brain, especially nervous system development.

Axelsson E, Ratnakumar A, Arendt ML, Maqbool K, Webster MT, Perloski M, Liberg O, Arnemo JM, Hedhammar A, Lindblad-Toh K. "The Genomic Signature of Dog Domestication Reveals Adaptation to a Starch-Rich Diet." *Nature*. 2013 Mar 21;495(7441):360-4. doi: 10.1038/nature11837. Epub 2013 Jan 23.

## Introducing Michele Koltookian: Making Science from Samples



When dog owners send samples to the Broad Institute, Michele Koltookian is the first person to receive these invaluable donations. As the sample database coordinator for the dog disease research team at the Broad, she enters the detailed information into the database, which currently has samples from nearly 17,000 dogs from over 100 breeds.

Koltookian, who has been on the dog research team for six years, serves as the main contact for dog owners and research collaborators alike. She also performs hands-on laboratory work on all of the samples by extracting the DNA used for genotyping and sequencing, two of the main tools in performing disease mapping. Her experience has given her a first-hand appreciation of the central role donated samples play in the Broad's research. "We can't begin to thank the dogs and the owners enough for the samples," she said. "Without you and your willingness to mail samples to us we would not be able to do our research. It literally would not be possible."

Dogs also play a central part in her personal life. Koltookian and her husband are the proud owners of Nax, a Tibetan terrier puppy who loves the great outdoors.



## Help Put a Leash on Disease – DNA Samples Still Needed

Several disease studies are in motion, and our collection of biological samples continues. To learn more about our current need for biological samples from select breeds diagnosed with the diseases being researched, and from older, healthy dogs of the same breeds please visit [broadinstitute.org/dogresearch](https://broadinstitute.org/dogresearch). To help support the work of our researchers with a financial contribution, please visit [broadinstitute.org/contribute](https://broadinstitute.org/contribute).

## About the Dog Research Program at the Broad Institute

In 2005, scientists sequenced the full dog genome from a boxer named Tasha. That work helped lay the foundation for a variety of studies into the genetic basis of disease — research that depends on help from dogs as well as their human companions. Dogs and humans get many of the same diseases, including cancer and diabetes. Studying DNA from both healthy and sick dogs can help researchers gain insights into diseases that affect both species.

Our dog disease researchers use canine DNA to study diseases because — thanks to the genetic diversity among breeds — the disease genes are easier to find. To find disease genes for complex diseases in humans, thousands of people and millions of genomic markers (SNPs) are needed. In dogs, twenty thousand markers and a few hundred dogs can suffice to find genes for complex diseases.

With the help of people and their canine companions, we hope to continue identifying risk factors in many more diseases in a step toward better understanding the overall health risks for dogs and humans alike.

## Ethical Statement

The Broad Institute's Canine Disease Mapping group performs disease research under a conservative ethical model so that no harm should come to the dogs. Dogs enrolled in our studies are pet dogs, participating after owner consent, only in ways that do no harm.

We do not induce cancer or other diseases in dogs, nor do we ever keep any animals in the laboratory.

For more information on Dog Disease Research at the Broad Institute: **Visit our website at [broadinstitute.org/dogresearch](https://broadinstitute.org/dogresearch)** or send an email to [dog-info@broadinstitute.org](mailto:dog-info@broadinstitute.org)