9-7-2015

The reliability of DNA tests for inherited diseases

Which of the internationally offered DNA tests for inherited diseases are useful for creating healthy dog breeds in the Netherlands.

Maaike Fennema (3574717)

Prof. Dr. Jan Rothuizen
Dr. Peter Leegwater

Abstract

The change of the ''Wet Dieren'', by the Dutch government, requires the breeders to screen their parental dogs for inherited diseases. Since the breeders and the veterinarians have to apply the DNA tests and they do not have all the knowledge about these tests, this study aims to make a list including all the available DNA tests on the Dutch market. To know if the offered tests are substantiated, they will be evaluated using a set of criteria developed during this project. First, all the DNA tests were gathered from the four biggest laboratories for the Dutch market, Laboklin, VetGen, Van Haeringen and Optigen. This resulted in a list containing 120 different diseases. In this article the focus was on cardiovascular and blood diseases, metabolic and immune problems and eye disorders. If the DNA tests fulfil the criteria they will be published on the website of 'Expertisecentrum Genetica Gezelschapsdieren'. The most important criterion was that there was a peer reviewed article available about the mutation they tested on. So for all the DNA tests, articles were searched and reviewed. The research resulted in a list of in total 11 cardiovascular and blood diseases, 23 metabolic and immune problems and 27 eye disorders.

Introduction

Inherited diseases are the most common health and welfare problems in purebred animals in The Netherlands. The welfare of animals has become more important the last years since it has become a subject on the political agenda, as a result the 'Wet Dieren' (Lid 2.6 2c.) has been changed. Since the 1st of July 2014 breeders are required to do everything possible to produce healthy offspring. Due to this change, breeders are supposed to screen the parental dogs they use for breeding for inherited diseases. Inherited diseases are caused by a mutation or mutations in the DNA of the dog. DNA tests can show if these mutations are present in individual animals. If the breeders know if the parental dogs have a mutation for a particular disease it is possible to select a combination of parental animals which will produce offspring that is clinically healthy for the examined disease.

There are many DNA tests on the Dutch market, some of these tests are trustworthy but quite a few are not substantiated or even completely unsuited. For the veterinarian and for the breeder, who has to apply the test and has to convert the outcome of the DNA test into a proper breeding policy, it is difficult to know which tests they can use for a reliable outcome. By reviewing all the available tests in a scientifically sound manner it is possible to make a list of reliable tests, which can be used by veterinarians and breeders. The 'Expertisecentrum Genetica Gezelschapsdieren' of the faculty veterinary medicine will publish this list on their website so that the veterinarian and breeder can co-operate to breed purebred animals as healthy as possible. Another important application of DNA diagnostics for veterinarians, is that they can diagnose the genetic susceptibility of individuals in a population at young age, often before the onset of clinical disease. This permits the veterinarian to design an individual health program to prevent or decrease the clinical stage of the disease.

To evaluate if the DNA tests are useful, a list of criteria has been developed. To set up quality criteria for DNA tests it is necessary to understand which types of molecular genetic research exist and how they work. There are two main types of DNA tests. The first is based on a known mutation which causes the disease, which is the best and most used method to diagnose the mutation causing the inherited disease. The second type of test is a marker test which only marks the part of the chromosome where the unknown causal gene lies. This method can be used if the precise mutation is not yet known. It is a less certain method because the gene which is being tested on can no longer be linked to the mutation by recombination of the genes. Therefore the mutations test is preferred over the marker test. There are other factors which play a role in setting up the criteria. The published peer reviewed literature is an imported one. The articles about the mutations confirm that reliable research has been done and that the DNA test is based on valid evidence. It is also necessary to know for which breed the test is useful and how a mutation is inherited.

In this report all the DNA tests offered by the four biggest laboratories for the Netherlands, Laboklin, VetGen, Van Haeringen and Optigen, will be scientifically reviewed to determine the validity of these tests.

This research project aims (1) to develop criteria to review the quality and applicability of DNA tests available, and (2) to apply these criteria for the evaluation of the DNA test for dogs on the Dutch market. In this project the focus was on cardiovascular and blood diseases, metabolic and immune problems and eye disorders.

Material and methods

The project sets up a list of criteria for DNA tests on the Dutch market. A very important criterion which must comply with each test is the basis of a peer reviewed published article. When an article about a mutation is published it may be assumed that fundamental research is done and that methods and results have been accepted by peers in the research field. Tests based on such published results are considered reliable DNA tests. The articles should describe in which breed the mutation occurs and in which country the mutation is found. It is also useful to know how the disease is inherited and if the same disease is due to one mutation into different mutations in the same gene or even two mutations in different genes in different breeds. Because the list produced in this project is only about DNA tests useful in the Netherlands only the breeds that are bred in the Netherlands were included. The ''Raad van Beheer'' has a list of al dog breeds who are bred in the Netherlands. So this is also a criterion DNA tests in the definitive list must fulfil.

With the knowledge of the criteria the available literature in the PennGen database was used. In this database all the breeds are listed with the inherited diseases they can have and the mutation which can cause the diseases with a reference to the published manuscript. Also PubMed was searched to find other articles about the offered DNA tests and were reviewed to judge the utility and quality of the DNA tests.

To create the definitive list of valid DNA test all the tests available from the four biggest laboratories, active on the Netherlands market, were gathered. The four laboratories which were examined are Laboklin, VetGen, Van Haeringen and Optigen. All DNA tests were ordered by breed. This resulted a good overview of which tests are available. The length of the list required a division into different organ systems. This project focused on cardiovascular and blood diseases, metabolic and immune problems and eye disorders.

To know if all laboratories based their DNA tests on reliable articles a mail was sent to ask on which articles the DNA tests are based. These mails enclosed in the appendix. (Appendix 5) They all used the database of PennGen. After reviewing all these articles about the DNA tests a list with a lot of information about the DNA test was formed. For all offered DNA test it was assessed whether the mutation was known and how the research was done. On the basis of this information all the unsubstantiated DNA tests have been removed from the list so only the reliable tests are still on the list.

Results

By weighing the factors that are useful to determine if the DNA test are valid, the criteria were set up. First we have to know if there is literature available for the mutations where the DNA test are based on. It is also useful to know if a test is a marker or a mutation test. Mutation tests are better because they indicate the mutation itself so it is a 100% sure the tested dog has the mutation. It is also important to known how the effect of the mutation inherited. Is it recessive or dominant and autosomal of X-linked or otherwise? To review all the literature, it was necessary to know which clinical criteria were used to select the case and control groups in DNA research as well as the steps to come to a valid test. It is also necessary to know which breed is used to determine the mutation because in different breeds different mutations may occur. If for example the mutation is found in a Beagle it is not sure if a Labrador with the same disease had the same mutation. Finally, decisions regarding the remaining list should be made based on cost of the DNA test and the time needed for the test result.

The result of gathering all the available DNA tests from Laboklin, VetGen, Van Haeringen and Optigen is a long list with many DNA tests. At this point the list contained 120 different diseases and 188 different breeds. Not all the diseases were offered for each breed but the list at this moment contains 683 combinations of diseases and breeds. (See appendix 1) In this list all available DNA tests are sorted by breed, so it is visible per breed which inherited disease can be tested. In this list there is more information about each test. Mostly this is information that is found on the different sites of the laboratories. This list contains all the DNA tests available and does not say anything about the validity of the DNA tests.

As described above the list is divided into different organ systems because of the length of the list. This article is about blood diseases, metabolic and immune problems and eye disorders. The result of this was three different lists for the three different groups of diseases. (See appendix 2)

In order to obtain more information about the DNA tests and to know if all the available DNA tests are reliable, the literature was reviewed. The response to the mails we had sent to the laboratories was that they all used the database of PennGen for the relevant publications. (Appendix 5). There were many articles in the PennGen database which have been used. Other information was obtained reviewing the literature in PubMed. The result of this research is a new list with a lot more information about the DNA tests. (See Appendix 3)

Some of the test were very well described in the articles, for instance Copper toxicosis in Bedlington Terriers. In this article the mutation is very precisely described for the Bedlington Terriers. The mutation is a deletion in the exon 2 of the COMMD1 gene and this mutation is the main cause for copper toxicosis in the Belington Terrier (Forman, 2005). In this case it was very straightforward that this was a good DNA test. This was the case with many diseases of the list, for instance dry eye curly coat syndrome by the Cavalier King Charles Spaniel: this disease is caused by a deletion of a single base-pair in the FAM83H gene. (Forman, Oliver 2012) and also Pyruvate kinase deficiency in six different dog breeds (Basenjis, Cairn terrier, Westhighland white terrier, Labrador retriever, Pug and Beagle). For all these breeds different mutations were found. For the Labrador retriever, Westhighland white terrier and the Cairn terrier they found the same mutation, a C>T mutation that resulted in an early stop codon. In the Pug and the Beagle they found two different missense

mutations that resulted in loss of enzyme function. (Gultekin, 2012) For the Basenjis they also found a mutation in the gene so also for this breed the DNA test is validated. (Whitney, 1995)

An example of an incorrect test is Achromatopsia type 1 or day blindness. This is a DNA test offered for the Labrador retriever, although there is no peer reviewed published article about any genetic mutation. Therefore this was considered an unsubstantiated DNA test. The same applies for Haemophilia A (Factor VIII deficiency). There is no proof in any article that the mutation for this disease is has been found. Therefore this test can be considered unreliable, meaning it should not be offered.

For other diseases the mutation was known for one breed but also offered for different breeds, for example Factor VII deficiency. Factor VII is necessary for the initiation of coagulation of the blood. When a dog is deficient for this factor it will lead to a bleeding disorder. The article about the mutation only concerns the beagle. (Callan, 2006) Nevertheless the DNA test for this mutation is also offered for the giant schnauzer, the Airedale terrier, the Alaskan klee kai and the Scottish deerhound. For these dog breeds there are no scientific articles available, which means the DNA test is not supported in a scientifically manner.

In other cases when a DNA test is offered, the supporting article, which should support the test by describing the mutation, actually states that the study of the mutation has not yet revealed the gene. This is the case for dilated cardiomyopathy in the Doberman pincher. The article is about a large study with 141 Doberman pinchers. Even though they investigated many genes, they did not find the specific gene for this disease. (Mausberg, Theresa-Bernadette 2011) There were other articles available (Meurs, Kathryn 2012). For instance, one article described finding a 16-bp deletion in the PDK4 gene that is associated with cardiomyopathy in Doberman pinschers. However, another article responds to that with a research in the European population where no evidence was found for the PDK4 gene involved. (Owczarek-Lipska, 2013) This inconclusive information indicates the need for more research.

This is also the case for Von-Willebrands Disease. There are three types of this disease of which type 1 is the most common. Type 2 is less common but when a dog is affected the clinical symptoms are more severe. Moreover, type 3 is the rarest form, which is also the worst form a dog can suffer from. The DNA test is offered for all the Von-Willebrands Disease types and for a lot of breeds, especially Von-Willebrands Disease Type 1. This DNA test is available for eleven different dog breeds. The article about the mutation (Rieger, 1998) reveals there is no knowledge about the genetic background of Von-Willebrands Disease Type 1. For the other types a mutation was discovered only for a small number of dog breeds. So the test is available for a lot of breeds but only found in a couple of breeds. This is the same for primary lens luxation. This test is offered for 28 different breeds mostly terriers. In the article about the ADAMST17 gene they examined 30 different dog breeds. Only 17 of the screened breeds had the mutation in the ADAMTS17 gene. The other breeds do suffers from primary lens luxation but the mutation that causes the disease is not the ADAMTS17 gene or a different mutation is the same gene. (Gould, 2011) The available DNA test for the eleven remaining breeds are not supported by any literature.

A very difficult inherited disease is Progressive Retinal Atrophy. There are a lot of types of PRA and many genes play a role in this disease. One study was performed on the genes of PRA. (Downs, Louise 2014) They screened 231 dogs, representing 36 dog breeds, for 17 different mutations which cause PRA. The result of this large study was that 129 dogs were homozygous, 29 dogs were carriers and the remaining 73 dogs had no mutation on the

tested alleles. From all the 36 tested breed only in 21 breeds a mutations was found. Another interesting aspect is that the disease was found to be heterogeneous in 15 of these 21 breeds, so it is caused by at least two mutations. For 102 dogs the mutations remain unknown. These numbers indicate the complexity of this disease. In appendix 3 all the different types of PRA and the breeds are described.

It was also important to look if the same disease has different mutations in different breeds. This was the case for pyruvate kinase deficiency. The Basenjis, Cairn terrier, Westhighland White Terrier Labrador Retriever have the same mutation but the Pug end the Beagle have two different mutation for the same disease.

Since the list is only for Dutch breeder and veterinarians only the breeds that are registered by the ''Raad van Beheer'' are included. A couple examples of the breeds, for those who the tests are offered but the breeds are not registered, are the Alaskan klee kai, Italian Greyhound, Small Munsterlander, Polish Lowland Sheepdog. Another types of breeds are the breeds that are called differently in different countries. For instance the American shepherd and the Llewellin Setter. The American shepherd is the American name, whereas in Europe they call this breed the Australian shepherd. The Llewellin Setter is the pure strain form of the English setter. (Sparks, Troy 2002) Most of these breeds, which were not described in the literature, were already removed from the list since they do not have the mutation.

Through this research the 683 original combinations of DNA tests that are offered was reduced to only the good and substantiated DNA test. In appendix 4 the definitive list is included. The list contains eleven of cardiovascular and blood diseases, 23 metabolic and immune problems and 27 eye disorders.

Discussion/Conclusion

After setting the criteria for the DNA test, many criteria seemed very important. During the project the use all of the criteria was revised, for example 'in which country is the test designed?''. The tests are mostly designed in other countries than The Netherlands. In the articles it is often described where the dogs come from and therefore the country where the test is most likely made. However, this is difficult to establish for all the DNA tests so this criterion is considered less important. For the best results all the tests have to be tested in The Netherlands, which is an almost impossible task. There is also the criteria of how the DNA tests are developed. This was hard to examine because the literature was often only about the mutation. The laboratories make all the test themselves. (See the mails in appendix 5). The criteria about how the effects of the mutations inherit is useful because the dominant diseases are only useful to test if the disease only occurs in old aged dogs. Otherwise the disease can be seen before the dogs is used for breeding. The DNA tests are particularly useful in order to detect carriers of recessive diseases. The criteria of what kind of DNA test is conducted, marker of mutation test was a very important criteria. When the project progressed it appeared that all the offered DNA test were mutation test. The two criteria that are the most important are: (1) if there is literature available and (2) for which breed is the DNA test created? These were the two criteria to which all the DNA test must comply.

The reviewing the literature indicated some interesting findings. When gathering all the information from the laboratories sometimes two different names for the same disease was used. Mostly they had the same mutation so we could combine them. For example Van Haeringen called a disease Multidrug Resistance 1 while Laboklin called it Ivermectin hypersensitivity (MDR1 gene defect). Also the data base of PenGenn did not always provide the proper information. Some articles did not exist anymore so other articles were sought in PubMed. There were a couple of diseases which were offer for all breeds for example Thrombasthenia 2. The article is only about the Pyrenean Mountain Dog so all the other breeds are not supported. There were also difficulties with some breeds, for instance the collies. In America the collies are not divided in different breeds but in Europe there are a lot of different collies. Other breeds are not registered by the ''Raad van Beheer'' so we did not include them in the definitive list. Sometimes the laboratories claim they found a mutation by themselves for a particular breed. In this case there is no publication available so we cannot know whether these claims are substained. Von-Willebrand disease type 1 is a not so severe disease that is very common. Every dog, with the risk of this disease could be tested but that is a little exaggerated. It is also advisable only test the dogs who undergo surgery for example.

The overall conclusion of this project is that a lot of research has been on DNA tests and many of the offered DNA tests were valuable tests. However there are a lot of tests, which are not based on any peer reviewed articles or the articles were easily misinterpreted. In some cases it looked like there was a mutation found but actually there is more research necessary. Since the laboratories are still doing a lot of investigation on DNA tests, the list will be longer and more complete over the course of the next few years.

Reference

Aguirre, G. D., Baldwin, V., Pearce Kelling, S., Narfström, K., Ray, K., & Acland, G. M. (1998). Congenital stationary night blindness in the dog: Common mutation in the RPE65 gene indicates founder effect. *Molecular Vision, 4*, 23.

Ahonen, S., Arumilli, M., & Lohi, H. (2013). A CNGB1 frameshift mutation in papillon and phalène dogs with progressive retinal atrophy. *Plos One, 8*(8), e72122. doi:10.1371/journal.pone.0072122

Ameratunga, R., Winkelstein, J. A., Brody, L., Binns, M., Cork, L. C., Colombani, P., et al. (1998). Molecular analysis of the third component of canine complement (C3) and identification of the mutation responsible for hereditary canine C3 deficiency. *The Journal of Immunology, 160*(6), 2824-30.

Aronovich, E. L., Carmichael, K. P., Morizono, H., Koutlas, I. G., Deanching, M., Hoganson, G., et al. (2000). Canine heparan sulfate sulfamidase and the molecular pathology underlying sanfilippo syndrome type A in dachshunds. *Genomics, 68*(1), 80-4. doi:10.1006/geno.2000.6275

Benson. (2003). Mutations associated with neutropenia in dogs and humans disrupt intracellular transport of neutrophil elastase. *Nature Genetics, 35*(1), 90-96.

Benson, K., Li, F., Person, R., Albani, D., Duan, Z., Wechsler, J., et al. (2003). Mutations associated with neutropenia in dogs and humans disrupt intracellular transport of neutrophil elastase. *Nature Genetics, 35*(1), 90-6. doi:10.1038/ng1224

Beurlet, S., Krief, P., Sansonetti, A., Briend Marchal, A., Kiladjian, J., Padua, R., et al. (2011). Identification of JAK2 mutations in canine primary polycythemia. *Experimental Hematology, 39*(5), 542-5. doi:10.1016/j.exphem.2011.02.003

Boudreaux. (2011). P2Y12 receptor gene mutation associated with postoperative hemorrhage in a greater swiss mountain dog. *Veterinary Clinical Pathology, 40*(2), 202-206.

Boudreaux, M. K., & Catalfamo, J. L. (2001). Molecular and genetic basis for thrombasthenic thrombopathia in otterhounds. *American Journal of Veterinary Research, 62*(11), 1797-804.

Boudreaux, M. K., Wardrop, K. J., Kiklevich, V., Felsburg, P., & Snekvik, K. (2010). A mutation in the canine kindlin-3 gene associated with increased bleeding risk and susceptibility to infections. *Thrombosis and Haemostasis, 103*(2), 475-7. doi:10.1160/TH09-09-0571

Boudreaux, M., Catalfamo, J., & Klok, M. (2007). Calcium-diacylglycerol guanine nucleotide exchange factor I gene mutations associated with loss of function in canine platelets. *Translational Research, 150*(2), 81-92. doi:10.1016/j.trsl.2007.03.006

Boudreaux, M., & Martin, M. (2011). P2Y12 receptor gene mutation associated with postoperative hemorrhage in a greater swiss mountain dog. *Veterinary Clinical Pathology, 40*(2), 202-6. doi:10.1111/j.1939-165X.2011.00318.x

Brooks, M., Gu, W., Barnas, J., Ray, J., & Ray, K. (2003). A line 1 insertion in the factor IX gene segregates with mild hemophilia B in dogs. *Mammalian Genome, 14*(11), 788-95. doi:10.1007/s00335-003-2290-z

Callan, M. B., Aljamali, M. N., Margaritis, P., Griot Wenk, M. E., Pollak, E. S., Werner, P., et al. (2006). A novel missense mutation responsible for factor VII deficiency in research beagle colonies. *Journal of Thrombosis and Haemostasis, 4*(12), 2616-22. doi:10.1111/j.1538-7836.2006.02203.x

Cameron, J., Maj, M., Levandovskiy, V., MacKay, N., Shelton, G. D., & Robinson, B. (2007). Identification of a canine model of pyruvate dehydrogenase phosphatase 1 deficiency. *Molecular Genetics and Metabolism, 90*(1), 15-23. doi:10.1016/j.ymgme.2006.09.011

Database of PennGen. (2015). Retrieved June, 2015, from http://research.vet.upenn.edu/penngen/AvailableTests/TestsAvailableatLabsWorldwide/tabid/7620/Default.aspx

Davis, B., Toivio Kinnucan, M., Schuller, S., & Boudreaux, M. K. (2008). Mutation in beta1-tubulin correlates with macrothrombocytopenia in cavalier king charles spaniels. *Journal of Veterinary Internal Medicine, 22*(3), 540-5. doi:10.1111/j.1939-1676.2008.0085.x

Dekomien, G., Runte, M., Gödde, R., & Epplen, J. T. (2000). Generalized progressive retinal atrophy of sloughi dogs is due to an 8-bp insertion in exon 21 of the PDE6B gene. *Cytogenetics and Cell Genetics, 90*(3-4), 261-7.

Dodgson, S. E., Day, R., & Fyfe, J. C. (2012). Congenital hypothyroidism with goiter in tenterfield terriers. *Journal of Veterinary Internal Medicine, 26*(6), 1350-7. doi:10.1111/j.1939-1676.2012.01015.x

Downs, L. M., Bell, J. S., Freeman, J., Hartley, C., Hayward, L. J., & Mellersh, C. S. (2013). Late-onset progressive retinal atrophy in the gordon and irish setter breeds is associated with a frameshift mutation in C2orf71. *Animal Genetics, 44*(2), 169-77. doi:10.1111/j.1365-2052.2012.02379.x

Downs, L., Hitti, R., Pregnolato, S., & Mellersh, C. (2014). Genetic screening for PRA-associated mutations in multiple dog breeds shows that PRA is heterogeneous within and between breeds. *Veterinary Ophthalmology, 17*(2), 126-30. doi:10.1111/vop.12122

Erkens. (2009). Presence of the ABCB1 (MDR1) deletion mutation causing ivermectin hypersensitivity in certain dog breeds in belgium. *Vlaams Diergeneeskundig Tijdschrift, 78*(4), 256-260.

Evans, J. P., Brinkhous, K. M., Brayer, G. D., Reisner, H. M., & High, K. A. (1989). Canine hemophilia B resulting from a point mutation with unusual consequences. *Proceedings of the National Academy of Sciences of the United States of America, 86*(24), 10095-9.

Expertisecentrum genetica gezelschapsdieren. (2015). Retrieved June, 2015, from http://www.diergeneeskunde.nl/klinieken/expertisecentrum-genetica-gezelschapsdieren/

Forman, O. P., Boursnell, M. E. G., Dunmore, B. J., Stendall, N., van den Sluis, B., Fretwell, N., et al. (2005). Characterization of the COMMD1 (MURR1) mutation causing copper toxicosis in bedlington terriers. *Animal Genetics, 36*(6), 497-501. doi:10.1111/j.1365-2052.2005.01360.x

Forman, O., Penderis, J., Hartley, C., Hayward, L., Ricketts, S., & Mellersh, C. (2012). Parallel mapping and simultaneous sequencing reveals deletions in BCAN and FAM83H associated with discrete inherited disorders in a domestic dog breed. *PLOS Genetics, 8*(1), e1002462. doi:10.1371/journal.pgen.1002462

Fyfe, J. C., Hemker, S. L., Venta, P. J., Stebbing, B., & Giger, U. (2014). Selective intestinal cobalamin malabsorption with proteinuria (imerslund-gräsbeck syndrome) in juvenile beagles. *Journal of Veterinary Internal Medicine, 28*(2), 356-62. doi:10.1111/jvim.12284

Fyfe, J. C., Hemker, S. L., Venta, P. J., Fitzgerald, C. A., Outerbridge, C. A., Myers, S. L., et al. (2013). An exon 53 frameshift mutation in CUBN abrogates cubam function and causes imerslund-gräsbeck syndrome in dogs. *Molecular Genetics and Metabolism, 109*(4), 390-6. doi:10.1016/j.ymgme.2013.05.006

Gerber, K., Harvey, J., D'Agorne, S., Wood, J., & Giger, U. (2009). Hemolysis, myopathy, and cardiac disease associated with hereditary phosphofructokinase deficiency in two whippets. *Veterinary Clinical Pathology, 38*(1), 46-51. doi:10.1111/j.1939-165X.2008.00089.x

Giger, U., Smith, B. F., Woods, C. B., Patterson, D. F., & Stedman, H. (1992). Inherited phosphofructokinase deficiency in an american cocker spaniel. *Journal of the American Veterinary Medical Association, 201*(10), 1569-71.

Goldstein, O., Guyon, R., Kukekova, A., Kuznetsova, T. N., Pearce-Kelling, S. E., Johnson, J., et al. (2010). COL9A2 and COL9A3 mutations in canine autosomal recessive oculoskeletal dysplasia. *Mammalian Genome, 21*(7-8), 398-408. doi:10.1007/s00335-010-9276-4

Goldstein, O., Jordan, J. A., Aguirre, G. D., & Acland, G. M. (2013). A non-stop S-antigen gene mutation is associated with late onset hereditary retinal degeneration in dogs. *Molecular Vision, 19*, 1871-84.

Goldstein, O., Jordan, J., Aguirre, G., & Acland, G. (2013). A non-stop S-antigen gene mutation is associated with late onset hereditary retinal degeneration in dogs. *Molecular Vision, 19*, 1871-84.

Goldstein, O., Mezey, J., Boyko, A., Gao, C., Wang, W., Bustamante, C., et al. (2010). An ADAM9 mutation in canine cone-rod dystrophy 3 establishes homology with human cone-rod dystrophy 9. *Molecular Vision, 16*, 1549-69.

Goldstein, O., Mezey, J., Schweitzer, P., Boyko, A., Gao, C., Bustamante, C., et al. (2013). IQCB1 and PDE6B mutations cause similar early onset retinal degenerations in two closely related terrier dog breeds. *Investigative Ophthalmology & Visual Science, 54*(10), 7005-19. doi:10.1167/iovs.13-12915

Gornik. (2014). Canine multifocal retinopathy caused by a BEST1 mutation in a boerboel. *Veterinary Ophthalmology, 17*(5), 368-372.

Gould, D., Pettitt, L., McLaughlin, B., Holmes, N., Forman, O., Thomas, A., et al. (2011). ADAMTS17 mutation associated with primary lens luxation is widespread among breeds. *Veterinary Ophthalmology, 14*(6), 378-84. doi:10.1111/j.1463-5224.2011.00892.x

Gould, D. (2011). ADAMTS17 mutation associated with primary lens luxation is widespread among breeds. *Veterinary Ophthalmology, 14*(6), 378-384. doi:10.1111/j.1463-5224.2011.00892.x

Gregory, B. L., Shelton, G. D., Bali, D. S., Chen, Y., & Fyfe, J. C. (2007). Glycogen storage disease type IIIa in curly-coated retrievers. *Journal of Veterinary Internal Medicine, 21*(1), 40-6.

Gu, W., Brooks, M., Catalfamo, J., Ray, J., & Ray, K. (1999). Two distinct mutations cause severe hemophilia B in two unrelated canine pedigrees. *Thrombosis and Haemostasis, 82*(4), 1270-5.

Gultekin, G. I., Raj, K., Foureman, P., Lehman, S., Manhart, K., Abdulmalik, O., et al. (2012). Erythrocytic pyruvate kinase mutations causing hemolytic anemia, osteosclerosis, and seconday hemochromatosis in dogs. *Journal of Veterinary Internal Medicine, 26*(4), 935-44. doi:10.1111/j.1939-1676.2012.00958.x

Guziewicz, K. E., Zangerl, B., Lindauer, S. J., Mullins, R. F., Sandmeyer, L. S., Grahn, B. H., et al. (2007). Bestrophin gene mutations cause canine multifocal retinopathy: A novel animal model for best disease. *Investigative Ophthalmology & Visual Science, 48*(5), 1959-67. doi:10.1167/iovs.06-1374

Guziewicz, K., Zangerl, B., Lindauer, S., Mullins, R., Sandmeyer, L., Grahn, B., et al. (2007). Bestrophin gene mutations cause canine multifocal retinopathy: A novel animal model for best disease. *Investigative Ophthalmology & Visual Science, 48*(5), 1959-67. doi:10.1167/iovs.06-1374

Hoffmann, I., Guziewicz, K., Zangerl, B., Aguirre, G., & Mardin, C. (2012). Canine multifocal retinopathy in the australian shepherd: A case report. *Veterinary Ophthalmology, 15 Suppl 2*, 134-8. doi:10.1111/j.1463-5224.2012.01005.x

Hytonen. (2012). A novel GUSB mutation in brazilian terriers with severe skeletal abnormalities defines the disease as mucopolysaccharidosis VII. *Plos One, 7*(7), e40281.

Inal Gultekin, G., Raj, K., Lehman, S., Hillström, A., & Giger, U. (2012). Missense mutation in PFKM associated with muscle-type phosphofructokinase deficiency in the wachtelhund dog. *Molecular and Cellular Probes, 26*(6), 243-7. doi:10.1016/j.mcp.2012.02.004

Kijas, J. M., Bauer, T. R., Gäfvert, S., Marklund, S., Trowald Wigh, G., Johannisson, A., et al. (1999). A missense mutation in the beta-2 integrin gene (ITGB2) causes canine leukocyte adhesion deficiency. *Genomics, 61*(1), 101-7. doi:10.1006/geno.1999.5948

Kishnani, P. S., Bao, Y., Wu, J. Y., Brix, A. E., Lin, J. L., & Chen, Y. T. (1997). Isolation and nucleotide sequence of canine glucose-6-phosphatase mRNA: Identification of mutation in puppies with glycogen storage disease type ia. *Biochemical and Molecular Medicine, 61*(2), 168-77.

Kramer, J. W., Venta, P. J., Klein, S. R., Cao, Y., Schall, W. D., & Yuzbasiyan Gurkan, V. (2004). A von willebrand's factor genomic nucleotide variant and polymerase chain reaction diagnostic test associated with inheritable type-2 von willebrand's disease in a line of german shorthaired pointer dogs. *Veterinary Pathology, 41*(3), 221-8. doi:10.1354/vp.41-3-221

Kuchtey, J., Olson, L., Rinkoski, T., Mackay, E., Iverson, T. M., Gelatt, K., et al. (2011). Mapping of the disease locus and identification of ADAMTS10 as a candidate gene in a canine model of primary open angle glaucoma. *PLOS Genetics, 7*(2), e1001306. doi:10.1371/journal.pgen.1001306

Kukekova, A. V., Goldstein, O., Johnson, J. L., Richardson, M. A., Pearce-Kelling, S. E., Swaroop, A., et al. (2009). Canine RD3 mutation establishes rod-cone dysplasia type 2 (rcd2) as ortholog of human and murine rd3. *Mammalian Genome, 20*(2), 109-23. doi:10.1007/s00335-008-9163-4

Kukekova, A., Goldstein, O., Johnson, J., Richardson, M., Pearce Kelling, S., Swaroop, A., et al. (2009). Canine RD3 mutation establishes rod-cone dysplasia type 2 (rcd2) as ortholog of human and murine rd3. *Mammalian Genome, 20*(2), 109-23. doi:10.1007/s00335-008-9163-4

LeVine, D. N., Zhou, Y., Ghiloni, R. J., Fields, E. L., Birkenheuer, A. J., Gookin, J. L., et al. (2009). Hereditary 1,25-dihydroxyvitamin D-resistant rickets in a pomeranian dog caused by a novel mutation in the vitamin D receptor gene. *Journal of Veterinary Internal Medicine, 23*(6), 1278-83. doi:10.1111/j.1939-1676.2009.0405.x

Lipscomb, D. L., Bourne, C., & Boudreaux, M. K. (2000). Two genetic defects in alphaIIb are associated with type I glanzmann's thrombasthenia in a great pyrenees dog: A 14-base insertion in exon 13 and a splicing defect of intron 13. *Veterinary Pathology, 37*(6), 581-8.

Mausberg, T., Wess, G., Simak, J., Keller, L., Drögemüller, M., Drögemüller, C., et al. (2011). A locus on chromosome 5 is associated with dilated cardiomyopathy in doberman pinschers. *Plos One, 6*(5), e20042. doi:10.1371/journal.pone.0020042

Mauser, A. E., Whitlark, J., Whitney, K. M., & Lothrop, C. D. (1996). A deletion mutation causes hemophilia B in lhasa apso dogs. *Blood, 88*(9), 3451-5.

Mealey, K., & Meurs, K. (2008). Breed distribution of the ABCB1-1Delta (multidrug sensitivity) polymorphism among dogs undergoing ABCB1 genotyping. *Journal of the American Veterinary Medical Association, 233*(6), 921-4. doi:10.2460/javma.233.6.921

Meek, K., Kienker, L., Dallas, C., Wang, W., Dark, M. J., Venta, P. J., et al. (2001). SCID in jack russell terriers: A new animal model of DNA-PKcs deficiency. *The Journal of Immunology, 167*(4), 2142-50.

Mellersh, C., Pettitt, L., Forman, O., Vaudin, M., & Barnett, K. (2006). Identification of mutations in HSF4 in dogs of three different breeds with hereditary cataracts. *Veterinary Ophthalmology, 9*(5), 369-78. doi:10.1111/j.1463-5224.2006.00496.x

Mellersh, C. (2012). DNA testing and domestic dogs. *Mammalian Genome, 23*(1-2), 109-23. doi:10.1007/s00335-011-9365-z

Meurs, K. M., Lahmers, S., Keene, B. W., White, S. N., Oyama, M. A., Mauceli, E., et al. (2012). A splice site mutation in a gene encoding for PDK4, a mitochondrial protein, is associated with the development of dilated cardiomyopathy in the doberman pinscher. *Human Genetics, 131*(8), 1319-25. doi:10.1007/s00439-012-1158-2

Mischke, R., Kühnlein, P., Kehl, A., Langbein Detsch, I., Steudle, F., Schmid, A., et al. (2011). G244E in the canine factor IX gene leads to severe haemophilia B in rhodesian ridgebacks. *The Veterinary Journal, 187*(1), 113-8. doi:10.1016/j.tvjl.2010.01.017

Miyadera, K., Kato, K., Aguirre Hernández, J., Tokuriki, T., Morimoto, K., Busse, C., et al. (2009). Phenotypic variation and genotype-phenotype discordance in canine cone-rod dystrophy with an RPGRIP1 mutation. *Molecular Vision, 15*, 2287-305.

Miyadera, K., Kato, K., Aguirre-Hernández, J., Tokuriki, T., Morimoto, K., Busse, C., et al. (2009). Phenotypic variation and genotype-phenotype discordance in canine cone-rod dystrophy with an RPGRIP1 mutation. *Molecular Vision, 15*, 2287-305.

Mizukami, K., Chang, H., Ota, M., Yabuki, A., Hossain, M. A., Rahman, M. M., et al. (2012). Collie eye anomaly in hokkaido dogs: Case study. *Veterinary Ophthalmology, 15*(2), 128-32. doi:10.1111/j.1463-5224.2011.00950.x

Mizukami, K., Shoubudani, T., Nishimoto, S., Kawamura, R., Yabuki, A., & Yamato, O. (2012). Trapped neutrophil syndrome in a border collie dog: Clinical, clinico-pathologic, and molecular findings. *Journal of Veterinary Medical Science, 74*(6), 797-800.

Okawa, T., Yanase, T., Shimokawa Miyama, T., Hiraoka, H., Baba, K., Tani, K., et al. (2011). Prekallikrein deficiency in a dog. *Journal of Veterinary Medical Science, 73*(1), 107-11.

Olson, L. M., Rinkoski, T., Mackay, E. O., Iverson, T. M., Gelatt, K. N., Haines, J. L., et al. (2011). Mapping of the disease locus and identification of ADAMTS10 as a candidate gene in a canine model of primary open angle glaucoma. *PLOS Genetics, 7*(2), e1001306. doi:10.1371/journal.pgen.1001306

Owczarek-Lipska, M., Mausberg, T., Stephenson, H., Dukes-McEwan, J., Wess, G., & Leeb, T. (2013). A 16-bp deletion in the canine PDK4 gene is not associated with dilated cardiomyopathy in a european cohort of doberman pinschers. *Animal Genetics, 44*(2), 239. doi:10.1111/j.1365-2052.2012.02396.x

Parker, H., Kukekova, A., Akey, D., Goldstein, O., Kirkness, E., Baysac, K., et al. (2007). Breed relationships facilitate fine-mapping studies: A 7.8-kb deletion cosegregates with collie eye anomaly across multiple dog breeds. *Genome Research, 17*(11), 1562-71. doi:10.1101/gr.6772807

Perryman, L. E. (2004). Molecular pathology of severe combined immunodeficiency in mice, horses, and dogs. *Veterinary Pathology, 41*(2), 95-100. doi:10.1354/vp.41-2-95

Petersen-Jones, S. M., Entz, D. D., & Sargan, D. R. (1999). cGMP phosphodiesterase-alpha mutation causes progressive retinal atrophy in the cardigan welsh corgi dog. *Investigative Ophthalmology & Visual Science, 40*(8), 1637-44.

Pilorge. (2007). Advantages and limitations of DNA tests in veterinary ophthalmology in dogs. *Le Nouveau Praticien Veterinaire Canine - Feline,* (33), 27-31.

Rieger, M. (1998). Identification of mutations in the canine von willebrand factor gene associated with type III von willebrand disease. *Thrombosis and Haemostasis, 80*(2), 332-337.

Seppälä, E. H., Reuser, A. J. J., & Lohi, H. (2013). A nonsense mutation in the acid a-glucosidase gene causes pompe disease in finnish and swedish lapphunds. *Plos One, 8*(2), e56825. doi:10.1371/journal.pone.0056825

Sidjanin, D., Lowe, J., McElwee, J., Milne, B., Phippen, T., Sargan, D., et al. (2002). Canine CNGB3 mutations establish cone degeneration as orthologous to the human achromatopsia locus ACHM3. *Human Molecular Genetics, 11*(16), 1823-33.

Silverstein Dombrowski, D., Carmichael, K. P., Wang, P., O'Malley, T., Haskins, M., & Giger, U. (2004). Mucopolysaccharidosis type VII in a german shepherd dog. *Journal of the American Veterinary Medical Association, 224*(4), 553-7, 532.

Skelly, B. J., Sargan, D. R., Winchester, B. G., Smith, M. O., Herrtage, M. E., & Giger, U. (1999). Genomic screening for fucosidosis in english springer spaniels. *American Journal of Veterinary Research, 60*(6), 726-9.

Skelly, B. J., Wallace, M., Rajpurohit, Y. R., Wang, P., & Giger, U. (1999). Identification of a 6 base pair insertion in west highland white terriers with erythrocyte pyruvate kinase deficiency. *American Journal of Veterinary Research, 60*(9), 1169-72.

Slutsky, J., Raj, K., Yuhnke, S., Bell, J., Fretwell, N., Hedhammar, A., et al. (2013). A web resource on DNA tests for canine and feline hereditary diseases. *The Veterinary Journal, 197*(2), 182-187. doi:http://dx.doi.org/10.1016/j.tvjl.2013.02.021

Smith, B. F., Stedman, H., Rajpurohit, Y., Henthorn, P. S., Wolfe, J. H., Patterson, D. F., et al. (1996). Molecular basis of canine muscle type phosphofructokinase deficiency. *Journal of Biological Chemistry, 271*(33), 20070-4.

Sparks, T. D. (2002). *About llewenllin setter.* Retrieved June 25, 2015, from http://www.nalba.org/llewellin_setters.htm

Veranderingen wet dieren 1 juli 2014. (2014). Retrieved June, 2015, from https://www.knmvd.nl/actueel/nieuws/item/10848379/Veranderingen-Wet-Dieren-1-juli-2014

Verfuurden, B., Wempe, F., Reinink, P., van Kooten, P J S, Martens, E., Gerritsen, R., et al. (2011). Severe combined immunodeficiency in frisian water dogs caused by a RAG1 mutation. *Genes and Immunity, 12*(4), 310-3. doi:10.1038/gene.2011.6

Website of laboklin. (2015). Retrieved June, 2015, from http://www.laboklin.de/index.php?link=labogen/pages/html/en/home.html

Website of optigen. (2015). Retrieved June, 2015, from https://www.optigen.com/opt9_test.html

Website of van Haeringen
. (2015). Retrieved June, 2015, from https://www.vhlgenetics.com/Webshop/Dieren/Hond/tabid/256/catid/6/language/nl-NL/Default.aspx

Website of VetGen. (2015). Retrieved June, 2015, from http://vetgen.com/AllBreedsList.aspx

Wet dieren. (2014). Retrieved June, 2015, from http://wetten.overheid.nl/BWBR0030250/Hoofdstuk2/1/Artikel26/geldigheidsdatum_26-06-2015

Whitney, K. M., & Lothrop, C. D. (1995). Genetic test for pyruvate kinase deficiency of basenjis. *Journal of the American Veterinary Medical Association, 207*(7), 918-21.

Winkler, P., Gornik, K., Ramsey, D., Dubielzig, R., Venta, P., Petersen Jones, S., et al. (2014). A partial gene deletion of SLC45A2 causes oculocutaneous albinism in doberman pinscher dogs. *Plos One, 9*(3), e92127. doi:10.1371/journal.pone.0092127

Zangerl, B., Goldstein, O., Philp, A. R., Lindauer, S. J. P., Pearce-Kelling, S. E., Mullins, R. F., et al. (2006). Identical mutation in a novel retinal gene causes progressive rod-cone degeneration in dogs and retinitis pigmentosa in humans. *Genomics, 88*(5), 551-63. doi:10.1016/j.ygeno.2006.07.007

Zangerl, B., Goldstein, O., Philp, A., Lindauer, S. J. P., Pearce Kelling, S., Mullins, R., et al. (2006). Identical mutation in a novel retinal gene causes progressive rod-cone degeneration in dogs and retinitis pigmentosa in humans. *Genomics, 88*(5), 551-63. doi:10.1016/j.ygeno.2006.07.007

Zeng, R., Coates, J. R., Johnson, G. C., Hansen, L., Awano, T., Kolicheski, A., et al. (2014). Breed distribution of SOD1 alleles previously associated with canine degenerative myelopathy. *Journal of Veterinary Internal Medicine, 28*(2), 515-521. Retrieved from SCOPUS database.

Zhang, Q., Acland, G. M., Wu, W. X., Johnson, J. L., Pearce-Kelling, S., Tulloch, B., et al. (2002). Different RPGR exon ORF15 mutations in canids provide insights into photoreceptor cell degeneration. *Human Molecular Genetics, 11*(9), 993-1003.

Zhang, Q., Acland, G., Wu, W., Johnson, J., Pearce Kelling, S., Tulloch, B., et al. (2002). Different RPGR exon ORF15 mutations in canids provide insights into photoreceptor cell degeneration. *Human Molecular Genetics, 11*(9), 993-1003.

Appendix 1

Table 1 List with all the diseases.

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
All Breeds	Canine degenerative myelopathy (DM)	Autosomaal recessive	SOD1-gene	Laboklin	3-5 days
			SOD1-gene	Van Haeringen	<20 days € 79,50
	Hiplaxity 1/2	Multifactorial origin		Van Haeringen	<10 days € 39,50
	Hyperuricemia (HUU)	Autosomal recessive	SLC2A9 Gene	Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
	Maligant hyperthermia (MH)	Autosomal dominant		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Multidrug Resistance 1 (MDR1)	Autosomal recessive	MDR1 Gene	Van Haeringen	<10 days € 80,00
	Polycythemia	Autosomal dominant	JAK2 Gene	Van Haeringen	<10 days € 39,50
	Thrombasthenia 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
Airedale Terrier	Faktor VII - Deficiency	Autosomal recessive		Laboklin	3-5 days
				VetGen	$65.00 USD
	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
Alaskan Klee Kai	Faktor VII - Deficiency	Autosomal recessive		Laboklin	3-5 days
				VetGen	$65.00 USD
Alaskan malamute	Polyneuropathy 1	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Cone Degeneration (CD)	Autosomal recessive	CNGB3 Gene	Optigen	
American Bulldog	Neuronal ceroid lipofuscinosis (NCL) 10	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			CSTD Gene	VetGen	$65.00 USD
	Canine Multi-focal Retinopathy (CMR)	Autosomal recessive	VMD2 Gene	Optigen	US$95.00

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
American Cocker Spaniel	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
	FN (Familial Nephropathy)	Autosomal recessive		Van Haeringen	<10 days € 110,00
American Eskimo Dog	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
	Thrombopathia 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
American Hairless Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
American Pitbull Terrier	Cerebellar Ataxia / Neuronal ceroid lipofuscinosis (NCL), 4A	Autosomal recessive		Optigen	3-4 weeks $150
	Cone Rod Dystrophy 2 (CRD2)	Autosomal recessive		Optigen	<2 weeks $120
American Staffordshire Terrier	Cerebellar Ataxia / Neuronal ceroid lipofuscinosis (NCL), 4A	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	3-4 weeks $150
	Cone Rod Dystrophy 2 (CRD2)	Autosomal recessive		Van Haeringen	<25 days € 100,00
	Hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Australian Cattle Dog	Cystinuria	Autosomal dominant		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Myotonia Congenita 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
(sequel)Australian Cattle Dog					
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Australian Shepherd	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
			BEST1 gene	VetGen	$65.00 USD
			VMD2 Gene	Optigen	US$95.00
	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
			chromosome number 37	Optigen	$180
	Cyclic Neutropenia (CN)	Autosomal recessive		VetGen	$65.00 USD
	Hereditary Cataract (HC)	Autosomal dominant	HSF4 Gene	Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
		Autosomal co-dominant	HSF4-2 Gene	Optigen	$100
	Hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Cone Degeneration (CD)	Autosomal recessive	CNGB3 Gene	Optigen	$160
Australian Silky Terrier	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
Australian Stumpy Tail Cattle Dog	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
Basenjis	Pyruvate kinase deficiency (PK)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
				Optigen	$80
	Basenji Progressive Retinal Atrophy (bas PRA)	Autosomal recessive		Optigen	$95

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Basset	Thrombopathia	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	X-linked severe combined Immunodeficiency (X-SCID)	X-Chromosomal		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Beagle	Factor VII deficiency	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
				VetGen	$65.00 USD
	Primary open angle glaucoma (POAG)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			ADAMTS10	Optigen	$95
	Musladin-Lueke syndrome (MLS)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
	Cobalamin Malabsorption/cubilin deficiency	Autosomal recessive		Laboklin	3-5 weeks
	Neonatal cortical cerebellar abiotrophy (NCCD)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Osteogenesis Imperfecta	Autosomal dominant		Van Haeringen	<10 days € 39,50
	Pyruvate kinase Deficiency 3 (PKDef)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
Bearded Collie	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
Bedlington Terriers	Copper toxicosis	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
			Commd1	VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Bernese Mountain Dog	Von-Willebrands Disease Type 1	Autosomal dominant variable penetrance		Van Haeringen	<10 days € 89,00
				Laboklin	3-5 days
				VetGen	Binnen 2 weeks $65.00 USD
Bichon Frise	Macrothrombocytopenia (MTC)	Autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Black Russian Terrier	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Boerboel	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
			VMD2 Gene	Optigen	US$95.00
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Bolonka Zwetna	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
Border Collie	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	Mdr1 gene	Laboklin	1-2 weeks
	Neuronal ceroid lipofuscinosis (NCL) 5	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	$95
	Trapped Neutrophil Syndrome (TNS)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	$95
	Cobalamin Malabsorption/cubilin deficiency	Autosomal recessive	cubilin gene	Optigen	$95
Boston Terrier	Hereditary Cataract 2 (HSF4)	Autosomal recessive	HSF4 Gene	Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			HSF4 Gene	VetGen	$65.00 USD
			HSF4-1 Gene	Optigen	$100
	Cobalamin Malabsorption/cubilin deficiency	Autosomal recessive		Laboklin	3-5 weeks
Boxer	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Boykin Spaniel	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
			chromosome number 37	Optigen	$180
	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
Brazilian Terrier	Mucopolysaccharidose Type VII - 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Briard	Congenital stationary night blindness (CSNB)	Autosomal recessive	RPE65 gene	Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
			RPE65 Gene	Optigen	$135
Braittany Spaniel	C3 Deficiency	Autosomal recessive		Van Haeringen	<10 days € 39,50
Bull Dog	Canine Multifocal Retinopathy (CMR1 & CMR2)	Autosomal recessive	BEST1 gene	VetGen	$65.00 USD
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Bull Mastiff	Canine Multifocal Retinopathy (CMR1 & CMR2)	Autosomal recessive	BEST1 gene	VetGen	$65.00 USD
			VMD2 Gene	Optigen	US$95.00
	Dominant Progressive Retinal Atrophy (PRA)	Autosomal dominant		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	ong.2 weeks $120
Bull Terrier	Polycystic kidney disease (PKD1)	Autosomal dominant		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
Cairn Terrier	Globoid Cell Leukodystrophy / Krabbes Disease	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Pyruvate kinase deficiency (PK)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
Cane Corsos	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		van Haeringen	<10 days € 39,50
			BEST1 gene	VetGen	$65.00 USD
			VMD2 Gene	Optigen	US$95.00

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Cardigen Welsh Corgi	rcd3 Progressive Retinal Atrophy (rcd3 PRA)	Autosomal recessive		van Haeringen	<10 days € 39,50
				VetGen	$65.00 USD
			PDE6A Gene	Optigen	$80
Cavalier King Charles Spaniel	Dry eye curly coat syndrome (CCS)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
	Episodic Falling (EF)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<20 days € 59,50
	Muscular dystrophy (MD)	X-chromosomal-recessive		Laboklin	1-2 weeks
	Thrombocytopaenia	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Chesapeake Bay Retriever	Ectodermal dysplasia/Skin fragility syndrome (ED/SFS)	Autosomal recessive		Laboklin	1-2 weeks
	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
			DNM1 gene	Van Haeringen	<20 days € 59,50
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Chihuahua	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Chinese Crested Dog	Canine Multiple System Degeneration (CMSD)	Autosomal recessive		Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
	Von-Willebrands Disease Type 2	Autosomal recessive		VetGen	$65.00 USD
	rcd3 Progressive Retinal Atrophy (rcd3 PRA)	Autosomal recessive	PDE6A Gene	Optigen	$80
Chinese Foo Dog	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Clumber Spaniel	Pyruvate Dehydrogenase Phosphatase 1 (PDP1)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
Cockapoo	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		Optigen	$80
English Cocker Spaniel	Familial Nephropathy (FN)	Autosomal recessive		Van Haeringen	<10 days € 110,00
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		VetGen	$65.00 USD
				Optigen	$80
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Collies	Gray Collie Syndrome (Cyclic Neutropenia)	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Collie Eye Anomaly (CEA)	Autosomal recessive		Van Haeringen	<25 days € 140,00
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
			chromosome number 37	Optigen	$180
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	rcd2 Progressive Retinal Atrophy (rcd2 PRA)	Autosomal recessive		Van Haeringen	<25 days € 187,50
				Laboklin	1-2 weeks
				Optigen	$180
	Von-Willebrands Disease Type 2	Autosomal recessive		VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Coton de Tulear	Bandara's Neonatal Ataxia (BNAt)	Autosomal recessive	GRM1 gene	VetGen	$65.00 USD
				Van Haeringen	<10 days € 39,50
	CMR2 (Canine Multifocal Retinopathy)	Autosomal recessive		van Haeringen	<10 days € 39,50
			BEST1 gene	VetGen	$65.00 USD
			VMD2 Gene	Optigen	US$95.00
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				Laboklin	3-5 days
				VetGen	Binnen 2 weeks $65.00 USD
Curly Coated Retrievers	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
			DNM1 gene	Van Haeringen	<20 days € 59,50
	Glycogen Storage Disease GSD Type IIIa (GSDIIIa)	Autosomal recessive	AGL Gene	Van Haeringen	<20 days € 44,50
				Laboklin	1-2 weeks
	Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Autosomal recessive		VetGen	$65.00 USD
Czechoslovakian Wolfdog	Pituitary dwarfism	Autosomal recessive		Van Haeringen	<20 days € 69,50
				Laboklin	1-2 weeks
Dachshund	Osteogenesis Imperfecta	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Cone Rod Dystrophy 4-PRA (CRD4-PRA)	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Autosomal recessive		VetGen	$65.00 USD
	Progressive retinal atrophy (crd-PRA)	Autosomal recessive	NPHP4 gene	Laboklin	1-2 weeks
	Mucopolysaccharidosis Type IIIa	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Narcolepsy	Autosomal recessive		Van Haeringen	<20 days € 49,50
			Hcrtr2 Gene	Optigen	$130
	Neuronal ceroid lipofuscinosis (NCL) 1/2	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Dalmation	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Doberman Pincher	Albinism (White)	Autosomal recessive	OCA4 gene	VetGen	$65.00 USD
	Dilated Cardiomyopathy	Autosomal recessive		Van Haeringen	<10 days € 39,50
				VetGen	$65.00 USD
	Narcolepsy	Autosomal recessive		Van Haeringen	<20 days € 49,50
				Laboklin	1-2 weeks
			Hcrtr2 Gene	Optigen	$130
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Dogue de Bordeaux	Canine Multi-focal Retinopathy (CMR)	Autosomal recessive	VMD2 Gene	Optigen	US$95.00
Drentsche Patrijshond	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Dutch Kooiker	Von Willebrand disease 3 - 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
Dwarf Poodle	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
English Bulldog	Canine Multifocal Retinopathy (CMR1 & CMR2)	Autosomal recessive	BEST1 gene	VetGen	$65.00 USD
English Cocker Spaniel	Familial Nephropathy (FN)	Autosomal recessive		Van Haeringen	<10 days € 110,00
				Laboklin	1-2 weeks
				Optigen	$95
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
				Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
(sequel) English Cocker Spaniel	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		VetGen	$65.00 USD
				Optigen	$80
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
English Mastiff	Dominant Progressive Retinal Atrophy (PRA)	Autosomal dominant		Laboklin	1-2 weeks
	Canine Multifocal Retinopathy (CMR1 & CMR2)	Autosomal recessive	BEST1 gene	VetGen	$65.00 USD
English Setter	Neuronal ceroid lipofuscinosis (NCL) 8	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			CSTD gene	VetGen	$65.00 USD
	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95
English Shepherd	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
English Springer Spaniel	Fucosidosis	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	102 weeks
	Familial Nephropathy (FN)	Autosomal recessive		Laboklin	1-2 weeks
	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
				Optigen	$80
	Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Autosomal recessive		VetGen	$65.00 USD
	Tremor, X-linked	X-Chromosomal		Van Haeringen	<10 days € 39,50
English Toy Spaniel	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Entlebucher Mountain Dog	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Farm Collie	rcd2 Progressive Retinal Atrophy (rcd2 PRA)	Autosomal recessive		Van Haeringen	<25 days € 187,50
Finnish Hound	Cerebellar Ataxia, progressive early-onset	Autosomal recessive		Van Haeringen	<10 days € 39,50
			SEL1L gene	Laboklin	1-2 weeks
	Glycogen storage disease type II (Pompe Disease)	Autosomal recessive		Laboklin	1-2 weeks

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Finnish Lapphund	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
French Bulldog	Hereditary cataract (HC)	Autosomal recessive	HSF4 gene	Laboklin	1-2 weeks
			HSF4 Gene	VetGen	$65.00 USD
			HSF4-1 Gene	Optigen	$100
Frisian Water Dogs	SCID 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
Fox Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
German Pinscher	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
German Pointer	Junctional epidermolysis bullosa (JEB)	Autosomal recessive		Laboklin	1-2 weeks
	Von-Willebrands Disease Type 2	Autosomal recessive		Van Haeringen	<10 days € 69,00
				VetGen	$65.00 USD
				Laboklin	3-5 days
	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
German Shepherd	Canine Leukocyte Adhesion Deficiency (CLAD), Type 3	Autosomal recessive		Van Haeringen	<10 days € 39,50
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
	Mucopolysaccharidosis Type VII	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	Pituitary dwarfism	Autosomal recessive		Van Haeringen	<20 days € 69,50
				Laboklin	1-2 weeks
	Renal Cystadenocarcinoma and Nodular Dermatofibrosis	Autosomal dominant		VetGen	$65.00 USD
				Van Haeringen	<10 days € 39,50
German Shorthaired Pointer	Cone Degeneration	Autosomal recessive		Van Haeringen	<10 days € 39,50
			CNGB3 Gene	Optigen	$160

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
German Spaniel	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		Laboklin	1-2 weeks
German Spitz	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
German WIrehaired Pointer	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
	Von-Willebrands Disease Type 2	Autosomal recessive		VetGen	$65.00 USD
Giant Schnauzer	Factor VII - Deficiency	Autosomal recessive		Laboklin	3-5 days
				VetGen	$65.00 USD
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
	Neuroaxonal dystrophy (NAD)	Autosomal recessive		Van Haeringen	<10 days € 39,50
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Glen of Imaal Terrier	Cone Rod Dystrophy 3 (CRD3)	Autosomal recessive		Van Haeringen	<25 days € 100,00
			ADAM9 Gene	Optigen	$120
Golden Retriever	Epidermolysis bullosa, dystrophic (RDEB)	Autosomal recessive		Van Haeringen	<10 days € 39,50
	GR PRA1 (Progressive Retinal Atrophy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	$100
	GR PRA2 (Progressive Retinal Atrophy)	Autosomal recessive		Optigen	$100
	Ichthyosis 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Optigen	$120
	Muscular Dystrophy (GRMD)	X-Chromosomal		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Gordon Setter	Cerebellar Ataxia 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Great Dane	Centronuclear Myopathy (cnm)	Autosomal recessive		Laboklin	3-5 days
Great Pyrenees	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		van Haeringen	<10 days € 39,50
			VMD2 Gene	Optigen	US$95.00
Great Swiss Mountain Dog	Bleeding disorder due to P2RY12 defect	Mono, autosomaal recessief	P2RY12 Gene	Van Haeringen	<10 days € 39,50
Greyhound	Hereditary polyneuropathy (HN)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
				VetGen	$65.00 USD
			NDRG1 gene	Optigen	$95
Havanese	Haemophilia A (Factor VIII)	X-Chromosomal		Van Haeringen	<20 days € 49,50
				Laboklin	2-5 days
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Hokkaido	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
Husky	GM1-Gangliosidosis	Autosomal recessive		Laboklin	1-2 weeks
Irish Setters	Canine Leukocyte Adhesion Deficiency (CLAD), Type 1	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
				Optigen	$135
	Globoid cell leukodystrophy (Krabbe disease)	Autosomal recessive		Laboklin	1-2 weeks
	Neuronal ceroid lipofuscinosis (NCL) 8	Autosomal recessive		Van Haeringen	<10 days € 39,50
	rcd1 Progressive Retinal Atrophy (rcd1 PRA)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				Optigen	$120
			PDEB gene	VetGen	$65.00 USD
	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Irish Terrier	Digital Hyperkeratosis (Corny Feet)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
Irish Wolfhound	Startle Disease or Hyperekplexia	Autosomal recessive		Laboklin	1-2 weeks
Italian Greyhound	IG PRA1 (Progressive Retinal Atrophy)	Autosomal Dominant with Incomplete Penetrance		Optigen	$105
Jack Russell Terrier	Late onset ataxia (LOA)	Autosomal recessive	(CAPN1)-gene	Laboklin	1-2 weeks
	Primary Lens Luxation (PLL)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
	SCID	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
	Spinocerebellar ataxia (SCA)	Autosomal recessive		Laboklin	3-5 days
Jagd Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Japanese chin/spitz					
Karerlian Beardog	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Kerry Blue Terrier	Canine Multiple System Degeneration (CMSD)	Autosomal recessive		Laboklin	1-2 weeks
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Kelpie	Cerebellar Abiotrophy	Autosomal recessive		Van Haeringen	<10 days € 39,50
Kromfohrländer	Digital Hyperkeratosis (Corny Feet)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
Kuvasz	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Labrador Retriever	Centronuclear Myopathy (CNM or HMLR)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
	Cystinuria	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
			DNM1 gene	Van Haeringen	<20 days € 59,50
	Hereditary Nasal Parakeratosis (HNPK)	Autosomal recessive		Van Haeringen	<20 days € 91,50
				Laboklin	3-5 days
			SUV39H2 gene	Optigen	$120
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
	Myotubular myopathy (MTM)	X-Chromosomal		Van Haeringen	<10 days € 39,50
	Narcolepsy	Autosomal recessive		Van Haeringen	<20 days € 49,50
				Laboklin	1-2 weeks
			Hcrtr2 Gene	Optigen	$130
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Pyruvate kinase Deficiency (PKDef)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
	Retinal Dysplasia Retinal Folds+OculoSkeletal Dysplasia (RD+OSD) 1	Autosomal dominant (incomplete penetrance)		Van Haeringen	<10 days € 39,50
				Laboklin	4-6 weeks
				Optigen	$160
	Skeletal Dysplasia 2 (SD2)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Achromatopsia Type 1/Day Blindness	Autosomal recessive		Optigen	$100

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Lagotto Romagnolo	Juvenile epilepsy	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 werkdays
			LGI2 gene	Optigen	$95
Lakeland Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
Lancashire Heeler	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
	Primary Lens Luxation (PLL)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Landseer	Cystinuria	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
	Thrombopathia 3	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Lapponian Herder	Glycogen storage disease type II (Pompe Disease)	Autosomal recessive		Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	CMR (Canine Multi-focal Retinopathy)	Autosomal recessive	VMD2 Gene	Optigen	US$95.00
Large munsterlander	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Leonberger	Leonberger Polyneuropathy 1 (LPN1)	Autosomal recessive		Laboklin	1-2 weeks
Lhasa Apso	Hemophilia B (Facort IX deficiency)	X-linked recessive		VetGen	$65.00 USD
Llewellin Setter	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive	C2orf71 Gene	Optigen	$95
Longhaired Whippet	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Lucas Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
Maltese	Glycogen Storage Disease Type I (GSD I)	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Maltipoo	prcd Progressice Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
Manchester Terrier	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Markiesje	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Mastiffs	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
			VMD2 Gene	Optigen	US$95.00
	Dominant Progressive Retinal Atrophy (PRA)	Autosomal dominant		Van Haeringen	<10 days € 39,50
				Optigen	ong.2 weeks $120
	Macrothrombocytopenia (MTC)	Autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
McNab	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
Miniature American Shepherd	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
			VMD2 Gene	Optigen	US$95.00
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Cone Degeneration (CD)	Autosomal recessive	CNGB3 Gene	Optigen	$160
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Miniature Australian Shepherd	Canine Multi-focal Retinopathy (CMR)	Autosomal recessive	VMD2 Gene	Optigen	US$95.00
	Cone Degeneration (CD)	Autosomal recessive	CNGB3 Gene	Optigen	$160
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180
	Hereditary Cateract (HD)	Autosomal co-dominant	HSF4-2 Gene	Optigen	$100
Miniature Bull Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Miniature Pinscher	Cystinuria	Autosomal dominant		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
Miniature Poodle	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Miniature Schnauzer	Myotonia Congenita	Autosomal recessive		Van Haeringen	<20 days € 49,50
				Laboklin	3-5 days
	Type A Progressive Retinal Atrophy (Type A PRA)	Autosomal recessive		Van Haeringen	<25 days € 132,50
				Optigen	$160
	Persistent Muellerian Duct Syndrome (PMDS)	sex-limited autosomal recessive trait	MISRII Gene	Optigen	$95
Moyen Poodle	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
Newfoundland	Cystinuria	Autosomal recessive		Laboklin	3-5 days
			Gene SLC3A1	Van Haeringen	<10 days € 39,50
				VetGen	$65.00 USD
				Optigen	$80
Norfolk Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
Norwegian Elkhound	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Norwich Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
Nova Scotia Duck Tolling Retriever	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Old Danish Pointer	Congenital Myasthenic Syndrome	Autosomal recessive		Van Haeringen	<10 days € 39,50
Old English Sheepdog (Bobtail)	Cerebellar Ataxia 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	Primary ciliary Dyskinesia (PCD)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	Collie Eye Anomalie (CEA)	Autosomal recessive		Van Haeringen	<25 days € 140,00
Otterhound	Thrombasthenia	Autosomal recessive		Van Haeringen	<10 days € 39,50
Papillion	Pap-Progressive Retinal Atrophy 1 (Pap-PRA1)	Autosomal recessive		Van Haeringen	<25 days € 100,00
				Laboklin	1-2 weeks
				Optigen	$90
	Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Autosomal recessive		VetGen	$65.00 USD
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Parson Russell Terrier	Late onset ataxia (LOA)	Autosomal recessive	CAPN1 -gene	Laboklin	1-2 weeks
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
(sequel) Parson Russell Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
	Spinocerebellar ataxia (SCA)	Autosomal recessive		Laboklin	3-5 days
Patterdale Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Pembroke Welsh Corgi	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
Perro de Presa Canarios	CMR1 (Canine Multifocal Retinopathy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
			VMD2 Gene	Optigen	US$95.00
Phalene	Pap-Progressive Retinal Atrophy 1 (Pap-PRA1)	Autosomal recessive		Van Haeringen	<25 days € 100,00
				Laboklin	1-2 weeks
				Optigen	$90
Pitbull Terrier	Cone Rod Dystrophy 2 (CRD2)	Autosomal recessive		Van Haeringen	<25 days € 100,00
	hyperuricosuria (HU)	Autosomal recessive		VetGen	$65.00 USD
Polish Lowland Sheepdog	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95
Pomeranian	Vitamin D-deficiency rickets, type II	Autosomal recessive		Van Haeringen	<10 days € 39,50
Poodle	Neonatal Encephalopathy	Autosomal recessive	ATF2 Gene	Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
(sequel) Poodle	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
Portuguese Water Dog	GM1-Gangliosidosis	Autosomal recessive		Laboklin	1-2 weeks
				Optigen	$120
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Pug	Necrotizing Meningoencephalitis (NME)	Autosomal recessive (with variable penetrance)		Laboklin	1-2 weeks
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
	Pyruvate kinase Deficiency 2 (PKDef)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
Rat Terrier	Congenital Hypothyroidism (CHG) 3	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Rhodesian Ridgeback	Haemophilia B (factor IX deficiency)	X-chromosomal-recessive		Laboklin	3-5 days
				VetGen	$65.00 USD
Rough Collie	rcd2 Progressive Retinal Atrophy (rcd2 PRA)	Autosomal recessive		Van Haeringen	<25 days € 187,50
				Optigen	$180
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180
Saarloos Wolfdog	Pituitary dwarfism	Autosomal recessive		Van Haeringen	<20 days € 69,50
				Laboklin	1-2 weeks

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Samoyed	Familial Nephropathy (FN)	X-chromosomal-recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
	Retinal Dysplasia Retinal Folds+OculoSkeletal Dysplasia (RD+OSD) 2	Autosomal recessive		Van Haeringen	<25 days € 132,50
		Autosomal-dominant with incomplete penetrance		Laboklin	4-6 weeks
		Autosomal dominant with incomplete penetrance		Optigen	$160
	X Linked Progressive Retinal Atrophy 1 (XL PRA1)	X-Chromosomal		Van Haeringen	<10 days € 39,50
				Optigen	$150
Schapendoes	gPRA (Progressive Retinal Atrophy)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Schipperke	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Scottish Deerhound	Faktor VII - Deficiency	Autosomal recessive		Laboklin	3-5 days
				VetGen	$65.00 USD
Scottish Terrier	Von-Willebrands Disease Type 3	Autosomal recessive		Van Haeringen	<10 days € 49,50
				VetGen	$65.00 USD
				Laboklin	1-2 weeks
Sealyham Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Shetland Sheepdog	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Van Haeringen	<25 days € 140,00
			chromosome number 37	Optigen	$180
	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	Von-Willebrands Disease Type 3	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Shiba Inu	GM1 Gangliosidosis	Autosomal recessive		Van Haeringen	<10 days € 39,50
Shih Tzu	Prekallikrein deficiency	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Macrothrombocytopenia (MTC)	autosomal dominant	beta-1 tubulin gene	VetGen	$65.00 USD
Siberian Husky	X Linked Progressive Retinal Atrophy 1 (XL PRA1)	X-Chromosomal		Van Haeringen	<10 days € 39,50
				Optigen	$150
Silken Windhound	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180
Silky Terrier	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive	prcd Gene	Optigen	$195
Sloughi	rcd1a Progressive Retinal Atrophy (rcd1a PRA)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
			PDE6B gene	Optigen	$80
Small Munsterlander	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95
Smooth Collies	rcd2 Progressive Retinal Atrophy (rcd2 PRA)	Autosomal recessive		Van Haeringen	<25 days € 187,50
				Optigen	$180
	Collie Eye Anomaly (CEA)	Autosomal recessive	chromosome number 37	Optigen	$180
Soft-Coated Wheaten Terrier	Protein losing nephropathy (PLN)	Autosomal recessive		Laboklin	3-5 days
Spaniel breeds	Phosphofructokinase deficiency (PFK)	Autosomal recessive		Van Haeringen	<10 days € 39,50
Spanish Water Dog	Congenital Hypothyreosis (CHG)	Autosomal recessive		Laboklin	1-2 weeks
				Van Haeringen	<10 days € 39,50
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Stabijhoun	Von-Willebrands Disease Type 1	Autosomal dominant (variable penetrance)		Van Haeringen	<10 days € 89,00
				VetGen	Binnen 2 weeks $65.00 USD
				Laboklin	3-5 days

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Staffordshire Bull Terrier	Hereditary Cataract 2 (HSF4)	Autosomal recessive	HSF4 Gene	Van Haeringen	<10 days € 39,50
			HSF4 Gene	VetGen	$65.00 USD
			HSF4 gene	Laboklin	1-2 weeks
			HSF4-1 Gene	Optigen	$100
	L2-Hydroxyglutaric aciduria (L2-HGA)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
Sussex Spaniel	Pyruvate Dehydrogenase Phosphatase 1 (PDP1)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
				VetGen	$65.00 USD
Swedish Lapphund	Glycogen storage disease type II (Pompe Disease)	Autosomal recessive		Laboklin	1-2 weeks
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Teddy Roosevelt Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
		2-20% of carriers will develop condition		Optigen	$90
Tenterfield Terrier	Congenital Hypothyroidism (CHG) 2	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Tibetan Terrier	Neuronal ceroid lipofuscinosis (NCL)	Autosomal recessive		Laboklin	1-2 weeks
	Primary Lens Luxation (PLL)	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	3-5 days
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
	rcd4 Progressive Retinal Atrophy (rcd4 PRA)	Autosomal recessive		Laboklin	1-2 weeks
			C2orf71 Gene	Optigen	$95

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Toy Fox Terrier	Congenital Hypothyroidism (CHG) 3	Autosomal recessive		Van Haeringen	<10 days € 39,50
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Toy Poodle	Gangliosidosis, GM2, type II	Autosomal recessive		Van Haeringen	<10 days € 39,50
	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
Volpino Italiano	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Wäller	Hereditary cataract (HC)	Autosomal dominant	HSF4 gene	Laboklin	1-2 weeks
Weimaraner	Hypomyelination (Shaking Puppy Syndrome)	Autosomal recessive		Laboklin	1-2 weeks
Welsh Corgi	Muscular Dystrophy, Duchenne type (MDM)	X-Chromosomal		Van Haeringen	<10 days € 39,50
	rcd3 Progressive Retinal Atrophy (rcd3 PRA)	Autosomal recessive		Laboklin	1-2 weeks
	X-linked severe combined Immunodeficiency (X-SCID)	X-Chromosomal		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
Welsh Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Westhighland White Terrier	Globoid Cell Leukodystrophy / Krabbes Disease	Autosomal recessive		Van Haeringen	<10 days € 39,50
				Laboklin	1-2 weeks
	Pyruvate kinase deficiency (PK)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
Westphalia Terrier	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days

Breeds	*Disease*	*Mono/poly, recessive/dominant*	*Mutation*	*Which lab.*	*Results Time/Price*
Whippet	Collie Eye Anomalie (CEA)	Autosomal recessive		Laboklin	4-6 weeks
				Optigen	$180
	Muscular Hypertrophy	Autosomal dominant		Van Haeringen	<10 days € 39,50
		Autosomal recessive		Laboklin	1-2 weeks
	Phosphofructokinase deficiency (PFKD)	Autosomal recessive		Laboklin	1-2 weeks
				VetGen	$65.00 USD
White Shepherd	Ivermectin hypersensitivity (MDR1 gene defect)	Autosomal recessive	mdr1 gene	Laboklin	1-2 weeks
Whire-haired Fox Terrier	Primary lens luxation (PLL)	Autosomal recessive		Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
Wire-haired Pointer	Exercise induced collapse (EIC)	Autosomal recessive	DNM1 gene	Laboklin	3-5 days
Wolfdog	Dilated Cardiomyopathy	Autosomal recessive		Van Haeringen	<10 days € 39,50
Yorkshire Terrier	prcd Progressive Retinal Atrophy (prcd PRA)	Autosomal recessive		Van Haeringen	<25 days € 150,00
			prcd Gene	Optigen	$195
	Primary lens luxation (PLL)	Autosomal recessive		Laboklin	3-5 days
				Van Haeringen	<10 days € 39,50
		Carriers have a small chance of getting sick.		VetGen	$65.00 USD
		2-20% of carriers will develop condition		Optigen	$90
	L2-Hydroxyglutaric Aciduria	Autosomal recessive		VetGen	$65.00 USD

Appendix 2

Table 2 Cardiovascular and blood diseases

Diseases	*Breeds*		
Bleeding disorder due to P2RY12 defect	Great Swiss Mountain Dog		
Cyclic Neutropenia (CN) (Gray Collie Syndrome)	Australian Shepherd	Collies	
Dilated Cardiomyopathy	Doberman Pincher, Wolfdog		
Factor VII - Deficiency	Giant Schnauzer	Beagle	Airedale Terrier
	Alaskan Klee Kai	Scottish Deerhound	
Haemophilia A (Factor VIII)	Havanese		
Haemophilia B (Factor IX deficiency)	Rhodesian Ridgeback	Lhasa Apso	German Wirehaired Pointer
	Airedale Terrier	Bull Terrier	Cairn Terrier
	German Pointer		
Macrothrombocytopenia (MTC)	Boxer	Labrador Retriever	Bichon Frise
	Cavalier King Charles Spaniel	Shih Tzu	Poodle
	Chihuahua	Parson Russell Terrier	Miniature Poodle
	English Cocker Spaniel	Mastiffs	Maltese
	English Toy Spaniel	Jack Russell Terrier	Havanese
Polycythemia	All Breeds		
Thrombasthenia	Otterhound		
Thrombasthenia 2	All Breeds		
Thrombocytopaenia	Cavalier King Charles Spaniel		
Thrombopathia	Basset	Landseer	American Eskimo Dog
Von-Willebrands Disease Type 1	Bernese Mountain Dog	Stabijhoun	Poodle
	Coton de Tulear	Pembroke Welsh Corgi	Papillion
	Doberman Pincher	Manchester Terrier	Kerry Blue Terrier
	Drentsche Patrijshond	German Pinscher	
Von-Willebrands Disease Type 2	Chinese Crested Dog	German Wirehaired Pointer	German Pointer
	Collies		
Von-Willebrands Disease Type 3	Dutch Kooiker	Scottish Terrier	Shetland Sheepdog

Table 3 Metabolic and Immune problems

Diseases	*Breeds*		
C3 Deficiency	Brittany Spaniel		
Canine Leukocyte Adhesion Deficiency (CLAD), Type 1	Irish Setters		
Canine Leukocyte Adhesion Deficiency (CLAD), Type 3	German Shepherd		
Cobalamin Malabsorption/cubilin deficiency	Beagle	Border Collie	Boston Terrier
Congenital Hypothyreosis (CHG)	Spanish Water Dog		
Congenital Hypothyreosis (CHG) 2	Tenterfield Terrier	Rat Terrier	
Congenital Hypothyreosis (CHG) 3	Toy Fox Terrier		
Copper toxicosis	Bedlington Terriers		
Fucosidosis	English Springer Spaniel		
Glycogen Storage Disease GSD Type IIIa (GSDIIIa)	Curly Coated Retrievers		

Glycogen Storage Disease Type I (GSD I)	Maltese		
Ivermectin hypersensitivity (MDR1 gene defect)	Australian Shepherd	White Shepherd	Silken Windhound
	Bobtail	Shetland Sheepdog	McNab
	Border Collie	Longhaired Whippet	German Shepherd
	Collies	All Breeds	
Mucopolysaccharidose Type VII - 2	Brazilian Terrier		
Mucopolysaccharidosis Type IIIa	Dachshund		
Mucopolysaccharidosis Type VII	German Shepherd		
Phosphofructokinase deficiency (PFKD)	Spaniel breeds	Whippet	German Spaniel
	American Cocker Spaniel	English Springer Spaniel	English Cocker Spaniel
	Cockapoo		
Prekallikrein deficiency	Shih Tzu		
Pyruvate Dehydrogenase Phosphatase 1 (PDP1)	Clumber Spaniel	Sussex Spaniel	
Pyruvate kinase Deficiency (PKDef)	Basenjis	Labrador Retriever	Westhighland White Terrier
	Cairn Terrier		
Pyruvate kinase Deficiency 2 (PKDef)	Pug		
Pyruvate kinase Deficiency 3 (PKDef)	Beagle		
Severe combined Immunodeficiency (X-linked-SCID)	Basset	Welsh Corgi	
Severe combined Immunodeficiency (SCID)	Jack Russell Terrier		
Severe combined Immunodeficiency 2(SCID2)	Frisian Water Dogs		
Vitamin D-deficiency rickets, type II	Pomeranian		
Glycogen storage disease type II (Pompe Disease)	Finnish Hound	Lapponian Herder	Swedish Lapphund

Table 4 Eye disorders

Diseases	*Breeds*		
Achromatopsia Type 1/Day Blindness	Labrador Retriever		
Albinism (White)	Doberman Pincher		
Canine Multi-focal Retinopathy (CMR 1)	Australian Shepherd	American Bulldog	Dogue de Bordeaux
	Boerboel	Miniature Australian Shepherd	Lapponian Herder
	Cane Corsos	Perro de Presa Canarios	Miniature American Shepherd
	Great Pyrenees	Mastiffs	
Canine Multi-focal Retinopathy (CMR 2)	Coton de Tulear		
Canine Multi-focal Retinopathy (CMR1 & CMR2)	Bull Dog	Bull Mastiff	English Bulldog
	English Mastiff		
Collie Eye Anomalie (CEA)	Australian Shepherd	Miniature Australian Shepherd	Miniature American Shepherd
	Bearded Collie	Rough Collie	Silken Windhound
	Border Collie	Longhaired Whippet	Whippet
	Boykin Spaniel	Shetland Sheepdog	Collies
	Hokkaido	Sheepdogs	Nova Scotia Duck Tolling Retriever
	Lancashire Heeler	Smooth Collies	
Cone Degeneration (CD)	German Shorthaired Pointer	Miniature Australian Shepherd	Miniature American Shepherd

	Alaskan malamute	Australian Shepherd	
Cone Rod Dystrophy 2 (CRD2)	American Pitbull Terrier	Glen of Imaal Terrier	Pitbull Terrier
	American Staffordshire Terrier		
Cone Rod Dystrophy 4-PRA (CRD4-PRA)	Dachshund		
Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Curly Coated Retrievers	Papillion	English Springer Spaniel
	Dachshund		
Congenital stationary night blindness (CSNB)	Briard		
Dry eye curly coat syndrome (CCS)	Cavalier King Charles Spaniel		
Hereditary Cataract (HC)	Australian Shepherd	Wäller	Miniature Australian Shepherd
	French Bulldog		
Hereditary Cataract 2 (HSF4)	Boston Terrier	Staffordshire Bull Terrier	
Primary lens luxation (PLL)	American Eskimo Dog	Pug	Rat Terrier
	American Hairless Terrier	Sealyham Terrier	Teddy Roosevelt Terrier
	Australian Cattle Dog	Tenterfield Terrier	Tibetan Terrier
	Chinese Crested Dog	Patterdale Terrier	Parson Russell Terrier
	Chinese Foo Dog	Norwich Terrier	Norfolk Terrier
	Fox Terrier	Miniature Bull Terrier	Toy Fox Terrier
	Jack Russell Terrier	Volpino Italiano	Welsh Terrier
	Jagd Terrier	Westphalia Terrier	Whire-haired Fox Terrier
	Lakeland Terrier	Yorkshire Terrier	Lucas Terrier
	Lancashire Heeler		
Primary open angle glaucoma (POAG)	Beagle		
Progressive Retinal Atrophy (prcd PRA)	Maltipoo	Norwegian Elkhound	Finnish Lapphund
	American Cocker Spaniel	Nova Scotia Duck Tolling Retriever	German Spitz
	American Eskimo Dog	Poodle	Giant Schnauzer
	Australian Cattle Dog	Portuguese Water Dog	Golden Retriever
	Australian Shepherd	Schipperke	Karelian Beardog
	Australian Silky Terrier	Silky Terrier	Kuvasz
	Australian Stumpy Tail Cattle Dog	Spanish Water Dog	Labrador Retriever
	Bolonka Zwetna	Swedish Lapphund	Lapponian Herder
	Chesapeake Bay Retriever	Toy Poodle	Markiesje
	Chinese Crested Dog	Yorkshire Terrier	Miniature American Shepherd
	Cockapoo	Entlebucher Mountain Dog	Miniature Australian Shepherd
	Dwarf Poodle	English Shepherd	Miniature Poodle
	English Cocker Spaniel	Moyen Poodle	
Progressive Retinal Atrophy -Dominant- (PRA)	Bull Mastiff	Mastiffs	English Mastiff
Progressive Retinal Atrophy (Basenji PRA)	Basenjis		
Progressive Retinal Atrophy (crd-PRA)	Dachshund		
Progressive Retinal Atrophy (gPRA)	Schapendoes		
Progressive Retinal Atrophy (GR PRA1 and 2)	Golden Retriever		
Progressive Retinal Atrophy (IG PRA1)	Italian Greyhound		
Progressive Retinal Atrophy (rcd1 PRA)	Irish Setters	Sloughi	

Progressive Retinal Atrophy (rcd2 PRA)	Collies	Smooth Collies	Rough Collie
	Farm Collie		
Progressive Retinal Atrophy (rcd3 PRA)	Cardigen Welsh Corgi	Chinese Crested Dog	Welsh Corgi
Progressive Retinal Atrophy (rcd4 PRA)	Australian Cattle Dog	Tibetan Terrier	Small Munsterlander
	English Setter	Polish Lowland Sheepdog	Llewellin Setter
	Gordon Setter	Irish Setters	
Progressive Retinal Atrophy (Type A PRA)	Miniature Schnauzer		
Progressive Retinal Atrophy 1 (Pap-PRA1)	Papillion	Phalene	
Progressive Retinal Atrophy 1 (X Linked PRA1)	Samoyed	Siberian Husky	
Retinal Dysplasia Retinal Folds OculoSkeletal Dysplasia (RD+OSD) 1 and 2	Labrador Retriever	Samoyed	

Appendix 3

Cardiovascular system and blood disorders

Bleeding disorder due to P2RY12 defect
Great Swiss Mountain Dog Mutation described in article. (Boudreaux, 2011)

Cyclic Neutropenia (CN)
Australian Shepherd No article found about the mutation.
Collies Mutation described in article. (Benson, 2003)

Dilated Cardiomyopathy
Doberman Pincher This article is about that they do not know the mutation yet.
Wolfhound No article found about the mutation.
(Mausberg, Theresa-Bernadette 2011)

Factor VII - Deficiency
Giant Schnauzer No article found about the mutation
Beagle Mutation described in article (Callan, M B 2006)
Airedale Terrier No article found about the mutation
Alaskan Klee Kai Breed is not registered by the ''Raad van Beheer''
Scottish Deerhound The mutation is only described for the Beagle

Haemophilia A (Factor VIII)
Havanese No article found about the mutation

Haemophilia B (Factor IX deficiency)
Rhodesian Ridgeback Mutation described in article. (Mischke, 2011)
Airedale Terrier Mutation described in article. (Mauser, 1996)
Bull Terrier Mutation described in article. (Mauser, 1996)
Cairn Terrier Mutation described in article but no breed. (Evans, 1989)
German Pointer No article found about the mutation
German Wirehaired Pointer Mutation described in article. (Brooks, Marjory 2003)
Lhasa Apso Mutation described in article. (Mauser, 1996)

Macrothrombocytopenia (MTC)
Boxer Article in GenPenn is about another disease no other article found.
Cavalier King Charles Spaniel Mutation described in article (Davis, 2008)
Chihuahua, English Cocker Spaniel, English Toy Spaniel, Havanese, Jack Russell Terrier, Maltese, Mastiffs, Miniature Poodle, Parson Russell Terrier, Poodle, Shih Tzu, Bichon Frise, Labrador Retriever
The mutation only described in the Cavalier King Charles Spaniel.

Polycythemia
All Breeds Only tested on a couple of breeds
Maltese, poodle, Yorkshire Terrier and West Highland White Terrier Mutation described in article.
(Beurlet, Stephanie 2011)

Thrombasthenia
Otterhound Mutation described in article. (Boudreaux, 2001)

Thrombasthenia 2
All Breeds No article found about the mutation about all breeds.
Pyreneese Berghond Mutation described in article. (Lipscomb, 2000)

Thrombocytopaenia
Cavalier King Charles Spaniel No article found about the mutation.

Thrombopathia
Basset, American Eskimo Dog, Landseer Mutation described in article (Boudreaux, Mary 2007)

Von-Willebrands Disease Type 1
Bernese Mountain Dog, Coton de Tulear, Doberman Pincher, Drentsche Patrijshond, German Pinscher, Kerry Blue Terrier, Manchester Terrier, Papillion, Pembroke Welsh Corgi, Poodle, Stabyhoun. Article describes no mutation is yet found. (Rieger,M. 1998)
Von-Willebrands Disease Type 2
Chinese Crested Dog, Collies, German Pointer No article found about the mutation.
German wirehaired pointer Mutation described in article (Kramer, 2004)
Von-Willebrands Disease Type 3
Dutch Kooiker, Scottish Terrier, Shetland Sheepdog Mutation described in article (Rieger,M. 1998)

Metabolic and immune diseases

C3 Deficiency
Brittany Spaniel Mutation described in article (Ameratunga, 1998)

Canine Leukocyte Adhesion Deficiency (CLAD), Type 1
Irish Setters Mutation described in article (Kijas, 1999)
Canine Leukocyte Adhesion Deficiency (CLAD), Type 3
German shepherd Mutation described in article (Boudreaux, 2010)

Cobalamin Malabsorption/cubilin deficiency
Beagle Mutation described in article (Fyfe, 2014)
Border Collie Mutation described in article (Fyfe, John 2013)
Boston Terrier No article found about the mutation.

Congenital Hypothyreosis (CHG) 1,2 and 3
Spanish Water Dog, Rat Terrier, Toy Fox Terrier No article found about the mutation.
Tenterfield Terriër Mutation described in article (Dodgson, 2012)

Copper toxicosis
Bedlington Terriers Mutation described in article (Forman, 2005)

Fucosidosis
English springer spaniel Mutation described in article (Skelly, 1999)

Glycogen Storage Disease Type I (GSD I)
Maltese Mutation described in article (Kishnani, 1997)
Glycogen Storage Disease GSD Type IIIa (GSDIIIa)
Curly Coated Retrievers Mutation described in article (Gregory, Brittany 2007)

Ivermectin hypersensitivity (MDR1 gene defect)
All Breed Only tested on a couple of breeds
Australian Shepherd, Collies, Border Collie, Shetland Sheepdog, White Shepherd, German Shepherd Longhaired Whippet, Silken Windhound Mutation described in article (Mealey,Katrina 2008)
Bobtail No article found about the mutation.
McNab Breed is not registered by the ''Raad van Beheer''.

Mucopolysaccharidose Type VII - 2
Brazilian Terrier Mutation described in article (Hytonen, 2012)
Mucopolysaccharidosis Type VII
German Shepherd Mutation described in article (Silverstein Dombrowski, Deborah 2004)
Mucopolysaccharidosis Type IIIa
Dachshund Mutation described in article (Aronovich, E L 2000)

Phosphofructokinase deficiency (PFKD)
American Cocker Spaniel, German Spaniel, Whippetn Mutation described in article (Giger, U 1992)
Cockapoo No article found about the mutation.
English Cocker Spaniel No article found about the mutation.
English Springer Spaniel Mutation described in article (Smith, 1996)

Prekallikrein deficiency
Shih Tzu Mutation described in article (Okawa, Takumi 2011)

Pyruvate Dehydrogenase Phosphatase 1 (PDP1)
Clumber Spaniel, Sussex Spaniel Mutation described in article (Cameron, Jessie 2007)

Pyruvate kinase Deficiency (PKDef)
Basenjis Mutation described in article (Whitney, 1995)
Cairn Terrier Mutation described in article (Gultekin, 2012)
Westhighland White Terrier Mutation described in article (Skelly, 1999)
Labrador Retriever Mutation described in article (Gultekin, 2012)
Type 2 Pug Mutation described in article (Gultekin, 2012)
Type 3 Beagle Mutation described in article (Gultekin, 2012)

Severe combined Immunodeficiency (X-linked-SCID)
Basset, Welsh Corgi Mutation described in article (Perryman, 2004)
Severe combined Immunodeficiency (SCID)
Jack Russell Terrier Mutation described in article (Meek, 2001)
Severe combined Immunodeficiency 2(SCID2)
Frisian Water Dogs Mutation described in article (Verfuurden, 2011)

Trapped Neutrophil Syndrome (TNS)
Border Collie Mutation described in article (Mizukami, Keijiro 2012)

Vitamin D-deficiency rickets, type II
Pomeranian Mutation described in article. (LeVine, 2009)

Glycogen storage disease type II (Pompe Disease)
Finnish Hound No article found about the mutation
Lapponian Herder, Swedish Lapphund Mutation described in article (Seppälä, Eija 2013)

Eye diseases

Achromatopsia Type 1/Day Blindness
Labrador Retriever No article found about the mutation

Albinism (White)
Doberman Pincher Mutation described in article (Winkler, Paige 2014)

Canine Multi-focal Retinopathy (CMR)
Australian Shepherd Mutation described in article (Hoffmann, Ingo 2012)
Boerboel Mutation described in article (Gornik 2014)
Great Pyrenees, Mastiffs, Mutation described in article (Guziewicz, Karina 2007)
American Bulldog, Cane Corso, Dogue de Bordeaux, Miniature Australian Shepherd, Lapponian Herder, Bull Dog, Bull Mastiff, English Bulldog, English Mastiff
No article found about the mutation
Miniature American Shepherd, Perro de Presa Canarios Breeds are not registered by the ''Raad van Beheer''

Canine Multi-focal Retinopathy (CMR 2)
Coton de Tulear Mutation described in article (Guziewicz, Karina 2007)

Collie Eye Anomalie (CEA)
Australian Shepherd, Bearded Collie, Border Collie, Boykin Spaniel, Lancashire Heeler, Nova Scotia Duck Tolling Retriever, Sheepdogs, Shetland Sheepdog, Whippet, Collies, Longhaired Whippet, Miniature Australian Shepherd, Rough Collie, Smooth Collies Mutation described in article (Parker, Heidi 2007)
Hokkaido Mutation described in article. (Mizukami, Keijiro 2012)
Silken Windhound No article found about the mutation

Cone Degeneration (CD)
German Shorthaired Pointer, Alaskan malamute, Mutation described in article (Sidjanin, Duska 2002)
Australian Shepherd, Miniature Australian Shepherd No article found about the mutation

Cone Rod Dystrophy 2 (CRD2)
American Pitbull Terrier, American Staffordshire Terrier Mutation described in article. (Goldstein, Orly 2013)
Pitbull Terrier No article found about the mutation

Cone Rod Dystrophy 3 (CRD3)
Glen of Imaal Terrier Mutation described in article. (Goldstein, Orly 2010)

Cone Rod Dystrophy 4-PRA (CRD4-PRA)
Dachshund No article found about the mutation

Cone-Rod Dystrophy 1-PRA (Cord1-PRA)
Dachshund Mutation described in article (Miyadera, Keiko 2009)
English Springer Spaniel Mutation described in article (Downs, Louise 2014)
Papillion, Curly Coated Retriever No article found about the mutation

Congenital stationary night blindness (CSNB)
Briard Mutation described in article (Aguirre, 1998)

Dry eye curly coat syndrome (CCS)
Cavalier King Charles Spaniel Mutation described in article (Forman, Oliver 2012)

Hereditary Cataract (HC)
Australian Shepherd Mutation described in article (Mellersh, Cathryn 2006)
French Bulldog, Wäller, Miniature Australian Shepherd No article found about the mutation
Hereditary Cataract 2 (HSF4)
Boston Terrier, Staffordshire Bull Terrier Mutation described in article (Mellersh, Cathryn 2006)

Primary lens luxation (PLL)
Australian Cattle Dog, Chinese Crested Dog, Miniature Bull Terrier, Jack Russell Terrier, Jagd Terrier, Lancashire Heeler, , Parson Russell Terrier, Patterdale Terrier, Rat Terrier, Sealyham Terrier, Tenterfield Terrier, Tibetan Terrier, Toy Fox Terrier, Volpino Italiano, Welsh Terrier, Whire-haired Fox Terrier, Yorkshire Terrier
Mutation described in article (Gould, David 2011)
American Eskimo Dog, American Hairless Terrier, Chinese Foo Dog, Fox Terrier, Lakeland Terrier, Lucas Terrier, Norfolk Terrier, Norwich Terrier, Pug, Teddy Roosevelt Terrier, Westphalia Terrier.
No article found about the mutation

Primary open angle glaucoma (POAG)
Beagle Mutation described in article (Olson, Lana M 2011)

Progressive Retinal Atrophy (prcd PRA)
Maltipoo, Australian Silky Terrier, Bolonka Zwetna, English Shepherd, German Spitz, Giant Schnauzer, Schipperke No article found about the mutation
American Cocker Spaniel, American Eskimo Dog, Australian Cattle Dog, Australian Shepherd, Australian Stumpy Tail Cattle Dog, Chesapeake Bay Retriever, Chinese Crested Dog, Cockapoo,Dwarf Poodle, English Cocker Spaniel, Entlebucher Mountain Dog, Finnish Lapphund, Golden Retriever, Karelian Beardog, Kuvasz, Labrador Retriever, Lapponian Herder, Markiesje, Miniature Australian Shepherd, Miniature Poodle, Moyen Poodle, Norwegian Elkhound, Nova Scotia Duck Tolling Retriever, Poodle, Portuguese Water Dog, Silky Terrier, Spanish Water Dog, Swedish Lapphund, Toy Poodle, Yorkshire Terrier Mutation described in article (Zangerl, Barbara 2006)
Progressive Retinal Atrophy (Dominant-PRA)
Bull Mastiff, English Mastiff Mutation described in article. (Downs, Louise 2014)
Progressive Retinal Atrophy (Basenji PRA)
Basenjis Mutation described in article (Goldstein, Orly 2013)
Progressive Retinal Atrophy (gPRA)
Schapendoes Mutation described in article (Downs, Louise 2014)
Progressive Retinal Atrophy (GR PRA1)
Golden Retriever Mutation described in article (Downs, Louise 2014)
Progressive Retinal Atrophy (GR PRA2)
Golden Retriever Mutation described in article (Downs, Louise 2014)
Progressive Retinal Atrophy (IG PRA1)
Italian Greyhound No article found about the mutation
Progressive Retinal Atrophy (rcd1 PRA)
Irish Setters Mutation described in article (Downs, Louise 2014)
Sloughi Mutation described in article (Dekomien, G 2000)
Progressive Retinal Atrophy (rcd2 PRA)
Farm Collie, Rough Collies, Smooth Collies Mutation described in article (Kukekova, Anna V 2009)
Progressive Retinal Atrophy (rcd3 PRA)
Cardigen Welsh Corgi, Chinese Crested Dog Mutation described in article (Petersen-Jones, S M 1999)
Welsh Corgi No article found about the mutation

Progressive Retinal Atrophy (rcd4 PRA)

Australian Cattle Dog, Llewellin Setter,Polish Lowland Sheepdog,Small Munsterlander No article found about the mutation.

English setter No article found about the mutation.

Gordon setter, Irish Setters Mutation described in article (Downs, 2013)

Tibetan terrier Mutation described in article. (Downs, Louise 2014)

Progressive Retinal Atrophy (Type A PRA)

Miniature Schnauzer Mutation described in article (Downs, Louise 2014)

Progressive Retinal Atrophy 1 (Pap-PRA1)

Papillion, Phalene Mutation described in article (Ahonen, Saija 2013)

Progressive Retinal Atrophy 1 (X Linked PRA1)

Samoyed, Siberian Husky Mutation described in article (Zhang, Qi 2002)

Retinal Dysplasia Retinal Folds OculoSkeletal Dysplasia (RD+OSD) 1

Labrador Retriever, Samoyed Mutation described in article (Goldstein, Orly 2010)

Appendix 4

Cardiovascular system and blood disorders

Table 5 Definitive list for good DNA tests

Disease	*Breed*
Bleeding disorder due to P2RY12 defect	Great Swiss Mountain Dog
Cyclic Neutropenia (CN)	Collies
Factor VII - Deficiency	Beagle
Haemophilia B (Factor IX deficiency)	Rhodesian ridgeback
	Airedale Terrier
	Bull Terrier
	German wirehaired pointer
	Lhasa Apso
Macrothrombocytopenia (MTC)	Boxer
	Cavalier King Charles Spaniel
Polycythemia	Maltese
	Poodle
	Yorkshire Terrier
	West Highland White Terrier
Thrombasthenia	Otterhound
Thrombasthenia 2	Pyreneese Berghond
Thrombopathia	Basset
	American Eskimo Dog
	Landseer
Von-Willebrands Disease Type 2	German Wirehaired Pointer
Von-Willebrands Disease Type 3	Dutch Kooiker
	Scottish Terrier
	Shetland Sheepdog

Metabolic and immune diseases

Table 6 Definitive list for good DNA tests

Disease	*Breed*
C3 Deficiency	Brittany Spaniel
Canine Leukocyte Adhesion Deficiency (CLAD), Type 1	Irish Setters
Canine Leukocyte Adhesion Deficiency (CLAD), Type 3	German shepherd
Cobalamin Malabsorption/cubilin deficiency	Beagle
	Border Collie
Congenital Hypothyreosis (CHG) 2	Tenterfield Terriër
Copper toxicosis	Bedlington Terriers
Fucosidosis	English springer spaniel
Glycogen Storage Disease Type I (GSD I)	Maltese
Glycogen Storage Disease GSD Type IIIa (GSDIIIa)	Curly Coated Retrievers
Ivermectin hypersensitivity (MDR1 gene defect)	Australian Shepherd
	Collies
	Border Collie
	Shetland Sheepdog
	White Shepherd
	German Shepherd
	Longhaired Whippet
	Silken Windhound

Mucopolysaccharidose Type VII - 2	Brazilian Terrier
Mucopolysaccharidosis Type VII	German Shepherd
Mucopolysaccharidosis Type IIIa	Dachshund
Phosphofructokinase deficiency (PFKD)	American Cocker Spaniel
	German Spaniel
	Whippet
	English Springer Spaniel
Prekallikrein deficiency	Shih Tzu
Pyruvate Dehydrogenase Phosphatase 1 (PDP1)	Clumber Spaniel, Sussex Spaniel
Pyruvate kinase Deficiency (PKDef)	Basenjis
	Cairn Terrier
	Westhighland White Terrier
	Labrador Retriever
	Type 2 Pug
	Type 3 Beagle
Severe combined Immunodeficiency (X-linked-SCID)	Basset
	Welsh Corgi
Severe combined Immunodeficiency (SCID)	Jack Russell Terrier
Severe combined Immunodeficiency 2(SCID2)	Frisian Water Dogs
Trapped Neutrophil Syndrome (TNS)	Border Collie
Vitamin D-deficiency rickets, type II	Pomeranian
Glycogen storage disease type II (Pompe Disease)	Lapponian Herder
	Swedish Lapphund

Eye diseases

Table 7 Definitive list for good DNA tests

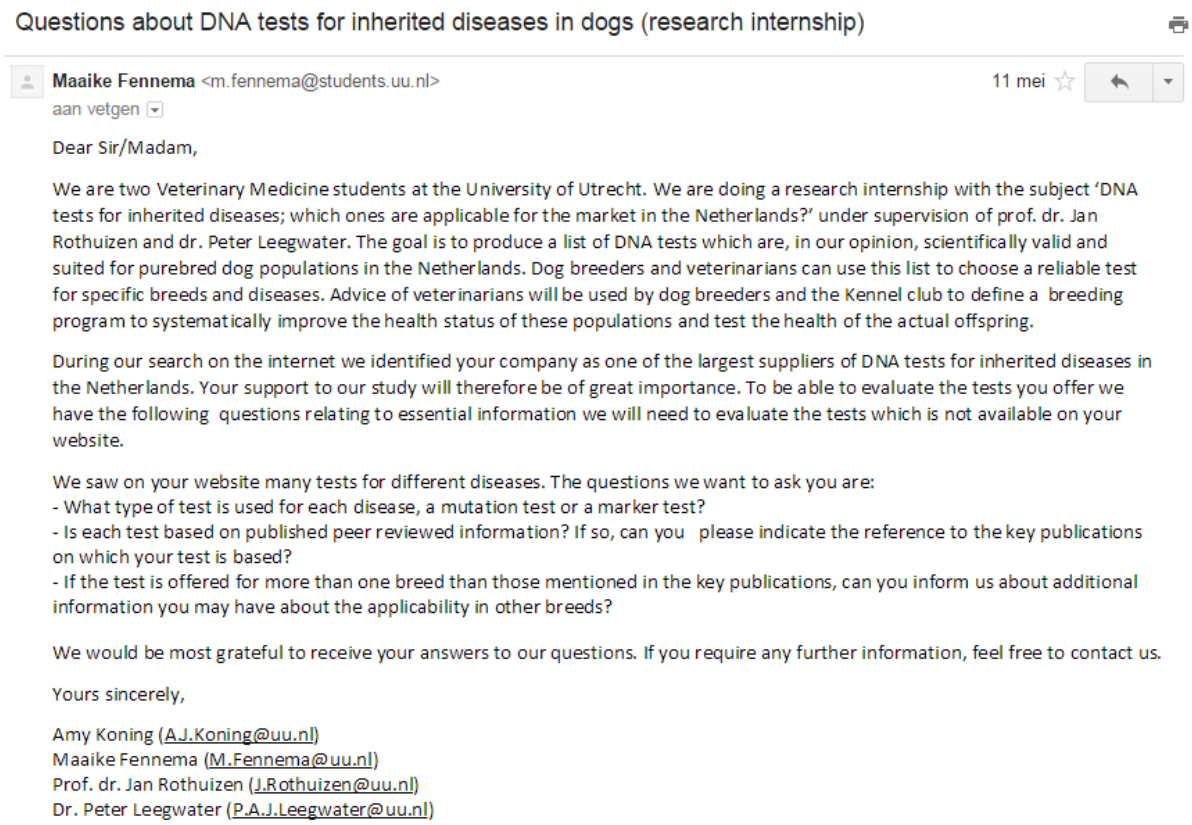
Disease	***Breed***
Albinism (White)	Doberman Pincher
Canine Multi-focal Retinopathy (CMR)	Australian Shepherd
	Boerboel
	Great Pyrenees
	Mastiffs
Canine Multi-focal Retinopathy (CMR 2)	Coton de Tulear
Collie Eye Anomalie (CEA)	Australian Shepherd
	Bearded Collie
	Border Collie
	Boykin Spaniel
	Hokkaido
	Lancashire Heeler
	Nova Scotia Duck Tolling Retriever
	Sheepdog
	Shetland Sheepdog
	Whippet
	Collies
	Longhaired Whippet
	Miniature Australian Shepherd
	Rough Collies
	Smooth Collies
Cone Degeneration (CD)	German Shorthaired Pointer
	Alaskan malamute
Cone Rod Dystrophy 2 (CRD2)	American Pitbull Terrier
	American Staffordshire Terrier
Cone Rod Dystrophy 3 (CRD3)	Glen of Imaal Terrier
Cone-Rod Dystrophy 1-PRA (Cord1-PRA)	Dachshund

	English Springer Spaniel
Congenital stationary night blindness (CSNB)	Briard
Dry eye curly coat syndrome (CCS)	Cavalier King Charles Spaniel
Hereditary Cataract (HC)	Australian Shepherd
Hereditary Cataract 2 (HSF4)	Boston Terrier
	Staffordshire Bull Terrier
Primary lens luxation (PLL)	Australian Cattle Dog
	Chinese Crested Dog
	Miniature Bull Terrier
	Jack Russell Terrier
	Jagd Terrier
	Lancashire Heeler
	Parson Russell Terrier
	Patterdale Terrier
	Rat Terrier
	Sealyham Terrier
	Tenterfield Terrier
	Tibetan Terrier
	Toy Fox Terrier
	Volpino Italiano
	Welsh Terrier
	Whire-haired Fox Terrier
	Yorkshire Terrier
Primary open angle glaucoma (POAG)	Beagle
Progressive Retinal Atrophy (prcd PRA)	American Cocker Spaniel
	American Eskimo Dog
	Australian Cattle Dog
	Australian Shepherd
	Australian Stumpy Tail Cattle Dog
	Chesapeake Bay Retriever
	Chinese Crested Dog
	Cockapoo
	Dwarf Poodle
	English Cocker Spaniel
	Entlebucher Mountain Dog
	Finnish Lapphund
	Golden Retriever
	Karelian Beardog
	Kuvasz
	Labrador Retriever
	Lapponian Herder
	Markiesje
	Miniature Australian Shepherd
	Miniature Poodle
	Moyen Poodle
	Norwegian Elkhound
	Nova Scotia Duck Tolling Retriever
	Poodle
	Portuguese Water Dog
	Silky Terrier
	Spanish Water Dog
	Swedish Lapphund
	Toy Poodle
	Yorkshire Terrier
Progressive Retinal Atrophy -Dominant- (PRA)	Bull Mastiff
	English Mastiff
Progressive Retinal Atrophy (gPRA)	Schapendoes

Progressive Retinal Atrophy (GR PRA1)	Golden Retriever
Progressive Retinal Atrophy (GR PRA2)	Golden Retriever
Progressive Retinal Atrophy (rcd1 PRA)	Irish Setters
	Sloughi
Progressive Retinal Atrophy (rcd2 PRA)	Farm Collie
	Rough Collies
	Smooth Collies
Progressive Retinal Atrophy (rcd3 PRA)	Cardigen Welsh Corgi
	Chinese Crested Dog
Progressive Retinal Atrophy (rcd4 PRA)	Gordon setter
	Irish Setters
	Tibetan terrier
Progressive Retinal Atrophy (Type A PRA)	Miniature Schnauzer
Progressive Retinal Atrophy 1 (Pap-PRA1)	Papillion,
	Phalene
Progressive Retinal Atrophy 1 (X Linked PRA1)	Samoyed
	Siberian Husky
Retinal Dysplasia Retinal Folds OculoSkeletal Dysplasia (RD+OSD) 1	Labrador Retriever
	Samoyed

Appendix 5

The mail sent to the Laboratories



Questions about DNA tests for inherited diseases in dogs (research internship)

Maaike Fennema <m.fennema@students.uu.nl> 11 mei

aan vetgen

Dear Sir/Madam,

We are two Veterinary Medicine students at the University of Utrecht. We are doing a research internship with the subject 'DNA tests for inherited diseases; which ones are applicable for the market in the Netherlands?' under supervision of prof. dr. Jan Rothuizen and dr. Peter Leegwater. The goal is to produce a list of DNA tests which are, in our opinion, scientifically valid and suited for purebred dog populations in the Netherlands. Dog breeders and veterinarians can use this list to choose a reliable test for specific breeds and diseases. Advice of veterinarians will be used by dog breeders and the Kennel club to define a breeding program to systematically improve the health status of these populations and test the health of the actual offspring.

During our search on the internet we identified your company as one of the largest suppliers of DNA tests for inherited diseases in the Netherlands. Your support to our study will therefore be of great importance. To be able to evaluate the tests you offer we have the following questions relating to essential information we will need to evaluate the tests which is not available on your website.

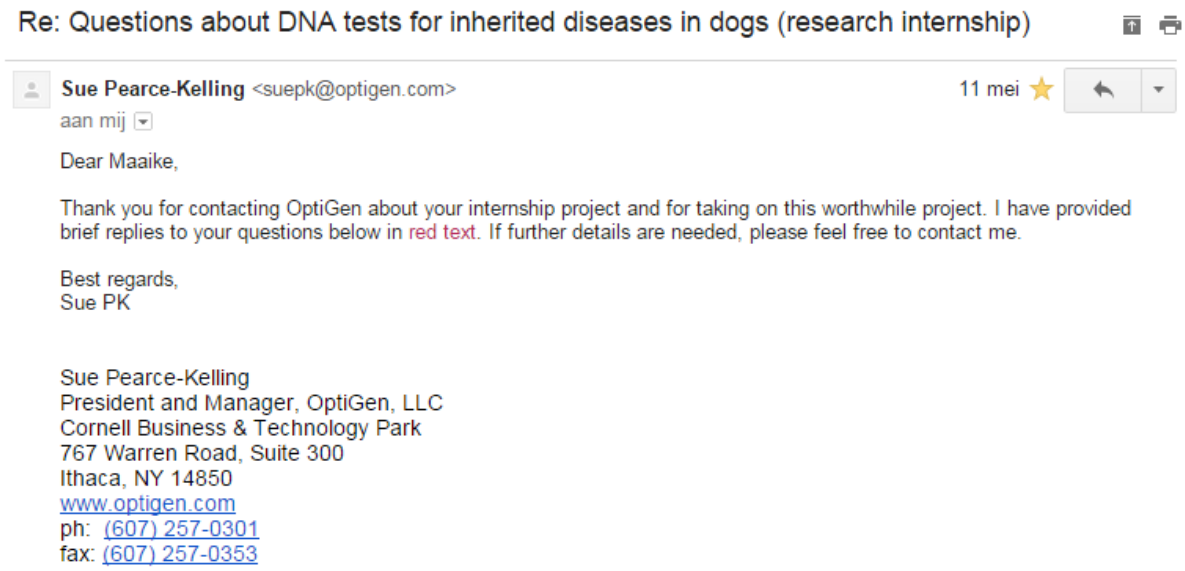
We saw on your website many tests for different diseases. The questions we want to ask you are:
- What type of test is used for each disease, a mutation test or a marker test?
- Is each test based on published peer reviewed information? If so, can you please indicate the reference to the key publications on which your test is based?
- If the test is offered for more than one breed than those mentioned in the key publications, can you inform us about additional information you may have about the applicability in other breeds?

We would be most grateful to receive your answers to our questions. If you require any further information, feel free to contact us.

Yours sincerely,

Amy Koning (A.J.Koning@uu.nl)
Maaike Fennema (M.Fennema@uu.nl)
Prof. dr. Jan Rothuizen (J.Rothuizen@uu.nl)
Dr. Peter Leegwater (P.A.J.Leegwater@uu.nl)

Answer from OptiGen



Re: Questions about DNA tests for inherited diseases in dogs (research internship)

Sue Pearce-Kelling <suepk@optigen.com> 11 mei

aan mij

Dear Maaike,

Thank you for contacting OptiGen about your internship project and for taking on this worthwhile project. I have provided brief replies to your questions below in red text. If further details are needed, please feel free to contact me.

Best regards,
Sue PK

Sue Pearce-Kelling
President and Manager, OptiGen, LLC
Cornell Business & Technology Park
767 Warren Road, Suite 300
Ithaca, NY 14850
www.optigen.com
ph: (607) 257-0301
fax: (607) 257-0353

We saw on your website many tests for different diseases. The questions we want to ask you are:
- What type of test is used for each disease, a mutation test or a marker test?Currently (as of 5/11/15), ALL of OptiGen's DNA tests are mutation, not marker, based.

- Is each test based on published peer reviewed information? If so, can you please indicate the reference to the key publications on which your test is based? Most of OptiGen's tests are based on published peer-reviewed information and all in that category are referenced in the WSAVA database: http://research.vet.upenn.edu/Default.aspx?TabId=7620 If you are not familiar with this useful site, I think you may find it very informative. Unfortunately, there is currently one important piece of information missing from this database—the mention of Intellectual Property (patents & licensing). As you may be aware, some of the DNA tests are governed by patents and licenses are required in order for a laboratory to use/sell the tests. You can find information on OptiGen's licensed tests on our webpage here: http://www.optigen.com/opt9_patent.html

- If the test is offered for more than one breed than those mentioned in the keypublications, can you inform us about additional information you may have about the applicability in other breeds? All of the tests that Optigen currently offers are mutation based and to the best of our knowledge, are typically fully penetrant, regardless of breed background. The prcd-PRA mutation, for example, has been shown to cause PRA in many more breeds than were initially known to carry the mutation at the time of the research paper publication (in 2005). We are aware that there can be some variations in age of onset and rate of disease progression, particularly in a couple of breeds that carry prcd. English Cocker Spaniels (ECS) that are homozygous for the prcd mutation often do not show clinical symptoms of PRA until they are over 7 years of age whereas most breeds that are homozygous for prcd show clinical symptoms of early-stage retinal degeneration by the time dogs are 3-4 years of age. We are very interested in understanding what modifiers in the ECS genetic background cause this delayed/slower retinal disease progression.

We would be most grateful to receive your answers to our questions. If you require

any further information, feel free to contact us.

Answer from VetGen

Questions about DNA tests for inherited diseases in dogs (research internship)

VetGen Laboratory <vetgen@vetgen.com> 11 mei

aan mij

FROM THE GENETICIST

Dear Amy and Maaike,

Our web site is a constant work in progress, but as for the current listings we can tell you that some have been developed in house while most are based on research done elsewhere. All of the primary publications for each test may be found on the WSAVA database hosted by UPenn.

http://research.vet.upenn.edu/Default.aspx?TabId=7620

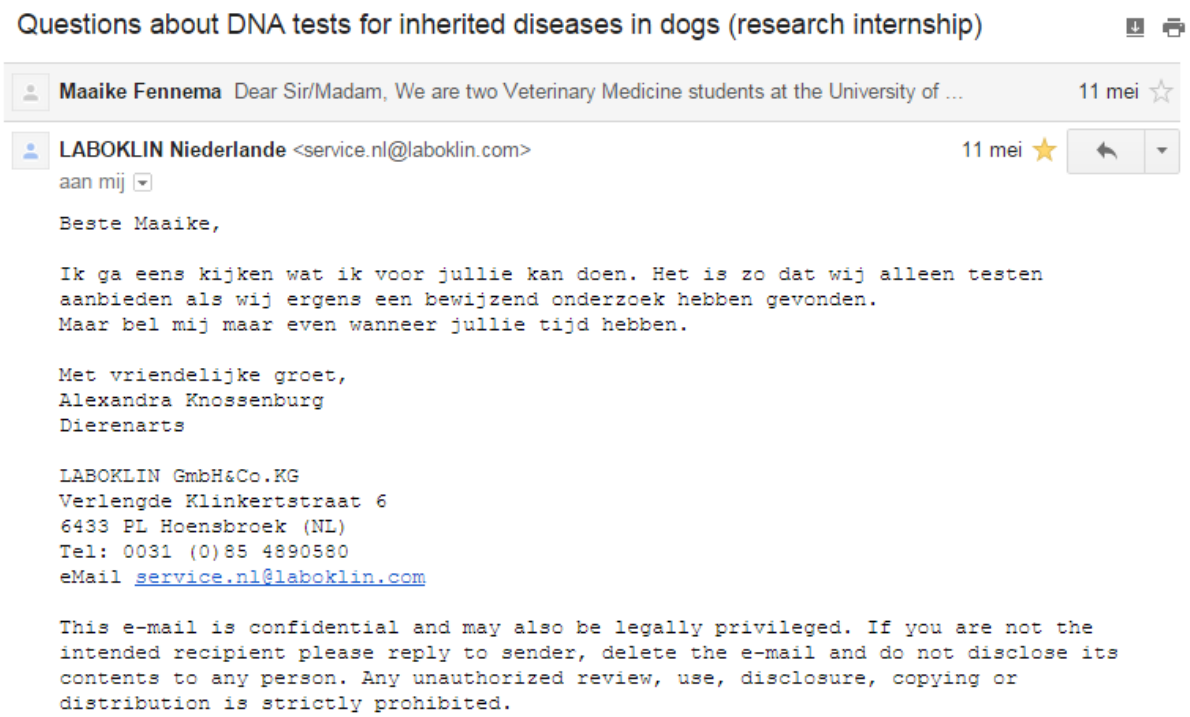
Here you can search by disease or breed, and primary publications where available will be listed. In the cases where we have breeds not listed in the primary publication, it is due either to reference in secondary publications as with many of the eye diseases, or detection of the mutation in our own research samples. In the case of all of the typeI vWD breeds, the additional breeds were added after correlation between the presence of the mutation and known bleeders with low ELISA numbers for most breeds.

Let us know if you have questions about any specific tests.

VetGen Customer Service

vetgen@vetgen.com

Answer from Laboklin



Questions about DNA tests for inherited diseases in dogs (research internship)

Maaike Fennema Dear Sir/Madam, We are two Veterinary Medicine students at the University of ... 11 mei

LABOKLIN Niederlande <service.nl@laboklin.com> 11 mei

aan mij

Beste Maaike,

Ik ga eens kijken wat ik voor jullie kan doen. Het is zo dat wij alleen testen aanbieden als wij ergens een bewijzend onderzoek hebben gevonden.
Maar bel mij maar even wanneer jullie tijd hebben.

Met vriendelijke groet,
Alexandra Knossenburg
Dierenarts

LABOKLIN GmbH&Co.KG
Verlengde Klinkertstraat 6
6433 PL Hoensbroek (NL)
Tel: 0031 (0)85 4890580
eMail service.nl@laboklin.com

This e-mail is confidential and may also be legally privileged. If you are not the intended recipient please reply to sender, delete the e-mail and do not disclose its contents to any person. Any unauthorized review, use, disclosure, copying or distribution is strictly prohibited.