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Health
OF
BELGIAN
SHEPHERDS

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CHAPTER 1: HISTORY AND GENETIC ORIGINS OF THE BELGIAN SHEPHERD – BASIS FOR HEALTH OR ILLNESS

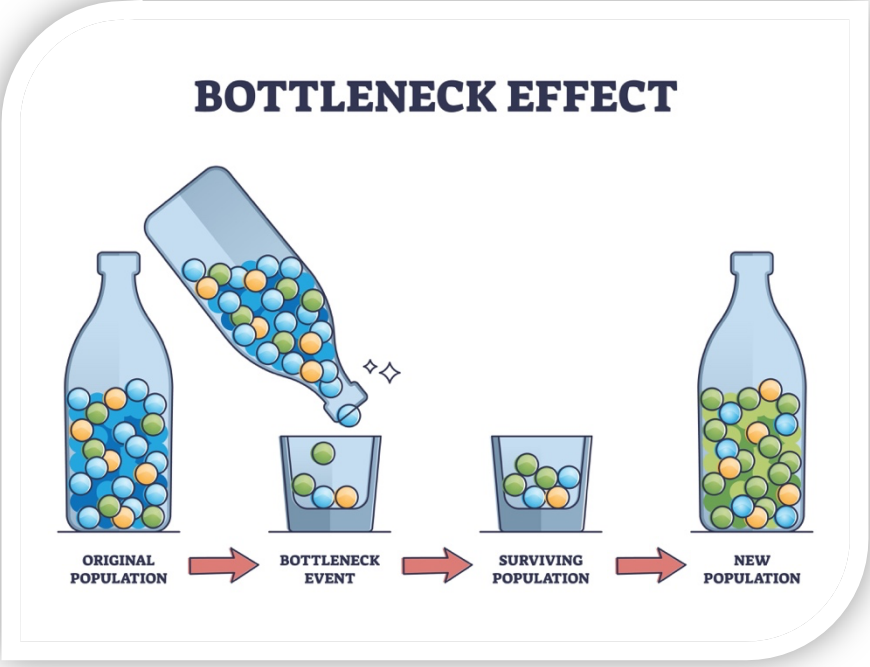
The story of the Belgian Shepherd is not only a story about shepherds and their collaborators, but it is a lesson in selective breeding and its far-reaching effects on the genome. When we look at the health of the breed in 2026, we need to go back to the moment when genetic diversity was narrowed down to match the aesthetic and functional ideal created by humans.

1.1. ADOLPHE REUL AND THE LEGACY OF CUREGHEM

In 1891, Professor Adolphe Reul assembled 117 dogs with the aim of unifying the scattered local herding dog population. At that time, dogs were variable in phenotype (appearance), but their genotype (genome) was rich.

Reuli's decision to divide the dogs according to their coat created the first **genetic bottlenecks**.

- **Artificial selection:** When only individuals of a certain color or hairy color were selected for breeding, a large part of the original, health-promoting gene variation was eliminated.
- **Founder Effect:** The thousands of Belgian Shepherds today are descended from a relatively small number of pedigree dogs. For example, if one of the few Groenendael pedigree dogs carried a recessive susceptibility to epilepsy, this defect multiplied rapidly in the population through inbreeding.



1.2. INBREEDING COEFFICIENT (COI) AND GENETIC TRUTH (GCOI%)

In this chapter, it is essential to understand the difference between traditional and modern computing. In the past, breeding science relied on pedigrees, but today we look directly at DNA.

1. **COI% (Coefficient of Inbreeding):** Calculated based on the pedigree. It is the mathematical probability that a dog will inherit the same allele from both parents.
    - *Limitation:* If there are deficiencies in the pedigree or if certain genes have been favored by a Mendelian lottery, the COI shown on paper (e.g., 2%) may be completely misleading.
2. **gCOI% (Genetic COI):** Measured directly from the genome by SNP analysis. It reveals the true **degree of homozygosity** – that is, what percentage of the dog's entire genome is identical from both parents.
    - *Importance for health:* The higher the gCOI, the greater the risk of developing latent diseases such as epilepsy or ataxia. High gCOI also correlates with a weaker immune system (lack of DLA diversity).

1.3. WORLD WARS: GENETIC COLLAPSE AND REVIVAL

World War I and World War II were biological disasters for the breed. The Malinois population, in particular, was in danger of disappearing completely.

- **Post-war breeding:** Very few surviving individuals were used to revive the population. To stabilize the type, very strict inbreeding was often used (e.g. father-daughter or full sister combinations).
- **The Roots of Epilepsy:** Many of the epilepsy risk lines identified today can be traced back to these post-war "hero dogs" that were used uncontrollably in population regeneration (the Popular Sire Effect).

1.4. VARIANT DIFFERENTIATION AND GENETIC ISOLATION

Although the Belgian Shepherd is officially a single breed, crossbreed bans between variants have created four distinct "genetic islands".

- **Analysis of fst values:** Scientific measurements show that the genetic distance between the variants has grown so great that they resemble completely different breeds in their genome.
- **Impact:** Once a variant is closed, its internal gCOI will inevitably increase. For example, the susceptibility to gastric cancer in the tervueren population is locked into certain lines precisely because of this isolation.

Chapter 1 Summary: The current health situation of the Belgian Shepherd is not a coincidence, but a consequence of historical choices, wars and artificial borders. By understanding the concept of gCOI, we can see that a pedigree clean on paper does not guarantee genetic health. We need to look deeper than the surface – into the dog's DNA sequence.

CHAPTER 2: WHY DOES THE BELGIAN SHEPHERD GET SICK? – GENETIC LOAD AND PHYSIOLOGICAL SENSITIVITY

The Belgian Shepherd has been bred to be the ultimate working dog. Its ability to react with lightning speed, withstand heavy physical exertion, and read even the smallest gestures of its handler has made it an unparalleled companion for official use and sports. However, it is precisely these characteristics – the high level of alertness of the nervous system and the well-defined selection – that carry with them a biological price.

2.1. POLYGENIC DISEASES: WHEN SEVERAL FACTORS COME TOGETHER

Unlike simple hereditary diseases such as ataxia (SDCA1/2), the majority of health problems in Belgian Shepherds are **polygenic**. This means that an unfavourable combination of dozens, perhaps hundreds, of different gene variants is required for the onset of the disease.

- **Additive effect:** A single "bad" gene does not make a dog sick, but when there are enough of these accumulated risk alleles, the threshold value is exceeded.
- **Epilepsy and polygenicity:** As we'll see in Chapter 5, idiopathic epilepsy isn't just a defect in one gene. Even if we recognize head genes (such as ADAM23), the rest of the dog's genome can either protect it or expose it to an electrical discharge. For this reason, two dogs with "in-between" status can produce very different levels of symptoms in their offspring.

2.2. NARROWING OF THE BREEDING BASE AND INCREASE IN HOMOZYGOSITY

An earlier version of your book mentioned the narrowness of the breeding base, but now we will look at it **through gCOI analysis**. When only a few popular males are favoured in a population (Popular Sire Effect), two critical things happen:

1. **Genetic Drift:** Rare but beneficial genes disappear from a population randomly because the dogs carrying them are not used.
2. **Growth of homozygosy:** The dog's genome becomes "self-repeating". When both parents are distantly related to each other (which is the rule, not the exception for Belgian Shepherds), long identical periods (Runs of Homozygosity, ROH) are created in the puppies' genome.
    - **Fact:** The more of these identical episodes (high gCOI), the more likely it is that harmful recessive mutations will occur. This explains why, in certain lines, "bad luck" seems to recur.

2.3. NEUROLOGICAL-IMMUNE CONNECTIVITY

A special feature of the Belgian Shepherd's nervous system is its low stimulus threshold. Biologically, this means that the braking mechanisms between neurons (the GABAergic system) are tuned to the extreme.

- **Arousal and epilepsy:** Constant high alertness (dominance of the sympathetic nervous system) means that the dog's brain is operating closer to the electrical threshold. Genetic predisposition to epilepsy finds "fertile ground" in such a nervous system.
- **DLA diversity of the immune system:** As previously stated, genes in the immune system (DLA) are located close to many neurological regulatory genes. When we strictly refine a particular utilization feature, we may accidentally narrow the DLA range.
    - **Result:** Low DLA diversity is directly correlated with allergies, autoimmune diseases (such as typical skin problems) and possibly also cancer susceptibility.

2.4. ENVIRONMENTAL FACTORS AND GENE EXPRESSION (EPIGENETICS)

Genes do not work in a vacuum. Chapter 9 deals with this in more detail, but it is important to understand at this point that the Belgian Shepherd is an environmentally sensitive breed.

- **Stress response:** Long-term stress experienced by a dog alters cortisol metabolism, which can "turn on" sleeping risk genes.
- **Nutritional support:** Because the breed is prone to neurological sensitivity, the role of nutrition (e.g., proper fatty acids) is more critical than in breeds with a more phlegmatic nervous system.

Chapter 2 summary: The Belgian Shepherd is sick because its breeding history has favored extreme reactivity, which has also narrowed genetic diversity. The polygenic load increases when homozygosity (gCOI) rises, and the sensitive nervous system is more susceptible to electrical and chemical imbalances. In other words, restoring health requires both genetic diversification and optimisation of the living environment.

CHAPTER 3: DOG PHYSIOLOGY – NERVOUS SYSTEM, IMMUNE SYSTEM, AND BIOCHEMICAL BALANCE

To understand the health of the Belgian Shepherd, we need to look at the dog as an integrated system. The nervous system is not just electrical wires, and the immune system is not just a defense wall; They are in constant chemical dialogue with each other. In the Belgian Shepherd, this dialogue is more intense than in many other breeds.

3.1. MICROSCOPIC ARCHITECTURE OF THE NERVOUS SYSTEM

As mentioned in your previous work, the nervous system is divided into the central nervous system (CNS) and the peripheral nervous system (PNS). Now, let's delve into what happens **in the synapse** – the junction between two neurons.

- **Synaptic Transmission:** The message travels as an electrical impulse along the stem of the neuron, but becomes chemical in the synaptic cleft. At this stage, neurotransmitters (such as glutamate or GABA) are released.
- **The role of ADAM23 in the synapse:** This is where new research data meets physiology. The ADAM23 protein acts as a "synaptic anchor" that ensures that the connection between neurons is mechanically and chemically stable.
    - **Fact:** If this anchor is weak due to a genetic defect, the synapse "leaks" or fires at the wrong time. This is the starting point of idiopathic epilepsy.

3.2. DELICATE BALANCE OF NEUROTRANSMITTERS (NEUROTRANSMITTERS)

The famous "motor" and reactivity of the Belgian Shepherd is directly due to its neurotransmitter profile.

- **Excitatory substances:** Glutamate and dopamine. They drive the dog to performance, predatory drive and attention.
- **Inhibitory (inhibitory) substances:** GABA (Gamma-aminobutyric acid). It is the brain's main brake that prevents overstimulation.
- **Connection to health:** Belgian Shepherds have been found to have a "braking system" that is often genetically tuned to tolerate massive amounts of acceleration. If this balance is upset – for example, due to stress or hereditary predisposition – the result is neurological overload, which can manifest as seizures or obsessive-compulsive behaviour.

3.3. BLOOD-BRAIN BARRIER – BARRIER AND ITS VULNERABILITY

The blood-brain barrier is a specialized cell membrane that prevents harmful substances from entering the brain tissue from the bloodstream.

- **MDR1 gene and drug sensitivity:** Although the MDR1 mutation (p-glycoprotein deficiency) is more common in Collie breeds, it is also an existing risk in Belgian Shepherds. If the barrier leaks, certain drugs (such as ivermectin) enter the brain directly, causing severe poisoning.
- **Epilepsy and the blood-brain barrier:** Recent research suggests that repeated epileptic seizures can damage this barrier, creating a vicious cycle: inflammatory reactions from the bloodstream enter the brain, further lowering the seizure threshold.

3.4. THE INTERSECTION OF THE IMMUNE SYSTEM AND THE NERVOUS SYSTEM

The Belgian Shepherd's immune system is exceptionally alert. This "hypervigilance" is not limited to observing the environment, but it also occurs at the cellular level.

- **Cytokines and neuroinflammation:** When a dog experiences stress or gets an infection, the immune system releases cytokines. These signaling molecules can cross the blood-brain barrier and directly affect mood and seizure sensitivity.
- **The importance of DLA diversity:** As discussed in Chapter 2, a narrow DLA genome (immune genes) means that a dog's immune system may "overreact" to its own cells (autoimmune diseases) or harmless particles (allergies).

3.5. AUTONOMIC NERVOUS SYSTEM: FIGHT OR FLIGHT

The Belgian Shepherd often lives in a state dominated by a sympathetic nervous system.

- **Sympathetic nervous system:** Prepares the body for action (heart rate increases, pupils dilate, digestion stops).
- **Parasympathetic nervous system:** "Rest and digest" – recovery and rest.
- **Physiological challenge:** For many Belgian Shepherds, recovery, i.e. the transition to a parasympathetic state, is slow. Continuous high cortisol levels consume the body's resources and expose you to chronic diseases such as gastrointestinal disorders and possibly even cellular changes (cancer).

Chapter 3 Summary: The physiology of the Belgian Shepherd is built for performance, but it operates on a narrow margin. The stability of synapses, the tightness of the blood-brain barrier and the balance of neurotransmitters are critical factors. When we understand these mechanisms, we also understand why medication, nutrition, and stress management are such central themes in this book.

CHAPTER 4: HEREDITY AND GENETICS – FROM CODE TO PRACTICE

The dog's genome is like a massive library that contains instructions for the construction and functioning of each cell. In the Belgian Shepherd, as a result of centuries of breeding, this library has become highly specialized, but at the same time vulnerable. In this chapter, we will analyze how code is passed down from one generation to the next and how modern technology helps us read it.

4.1. MENDELIAN VS. COMPLEX HEREDITY

Heredity is roughly divided into two categories, and the breeder must understand the difference between them:

1. **Monogenic (Mendelian) heredity:** The disease is caused by one specific genetic defect. An example of this is **SDCA1 and SDCA2 (ataxia)** in Belgian Shepherds. These are recessive traits: a dog needs a defective allele from both parents to get sick.
2. **Polygenic and complex heredity:** Most of the challenges faced by the Belgian Shepherd, such as **epilepsy, hip dysplasia, and susceptibility to cancer**, fall into this group. They are affected by hundreds of small genetic factors and the environment. At this point, a simple "yes/no" test is not enough, but a comprehensive risk assessment is needed.

4.2. THE REVOLUTION IN GENOMIC TESTING: SNP MARKERS

Previously, we only tested known mutations. Nowadays, we use **SNP** panels (Single Nucleotide Polymorphism) that scan tens of thousands of parts of the dog's genome at once.

- **gCOI (Genetic Coefficient of Inbreeding):** As mentioned in Chapter 1, SNP data reveals true homozygosity. If a dog has long identical periods in the DNA chain (Runs of Homozygosity), it indicates that the parents have been genetically very similar.
- **Analysis of DLA diversity:** With SNP tests, we can see if the dog has enough variation in the genes of the immune system. Low diversity in this area is often associated with the typical skin problems and allergies of the breed.

4.3. EPIGENETICS: HOW LIFE MODIFIES GENE EXPRESSION

One of the most important new concepts in the book is **epigenetics**. It explains why two genetically identical dogs can have different health.

- **Methylation:** Chemical "markers" can attach to DNA that turn off or turn on genes.
- **Role of the environment:** The mother's stress during pregnancy, the nutrition of the puppy and the strain the dog experiences change these signs.

- **Example:** A dog may carry a gene variant that predisposes to epilepsy, but an optimal environment and stress management can keep that gene "off" so that seizures never occur.

4.4. GENETIC COUPLING AND 'FREE RIDERS'

Genes are not inherited individually, but they travel in large packages (haplotypes).

- **Linkage Disequilibrium:** If we choose a dog with an extremely good chewing gene (a desirable trait) for breeding, we may accidentally select a gene in the same package that predisposes to gastric cancer, for example, if the two are located close to each other on the same chromosome.
- **Fact:** This is the reason why it is so difficult to "cleanse" the breed of diseases. We can't just remove the bad pieces without breaking the functioning of the whole at the same time.

4.5. ETHICAL CHALLENGES OF TESTING

An earlier version of your book discussed sustainability. In the new style, we emphasize the **interpretation of information**:

1. **No over-qualification:** If we remove every dog with a "risk allele" from breeding, we destroy the breed's gene pool.
2. **Controlled risk-taking:** The goal is to mate dogs so that their genetic weaknesses do not match (combining different haplotypes).

Chapter 4 summary: Genetics is no longer just about drawing pedigrees. It's complex math where SNP panels reveal true inbreeding (gCOI) and epigenetics remind us of the power of the environment. The breeder's job is to manage these risks, not to strive for impossible perfection. Information is a tool to avoid the realisation of linked risks.

CHAPTER 5: IDIOPATHIC EPILEPSY – THE GENETIC RIDDLE AND ITS SOLUTIONS

Idiopathic epilepsy is perhaps the most feared disease among Belgian Shepherds due to its unpredictability and often severe symptoms. The term "idiopathic" means that no structural cause (such as a tumor or injury) can be found for the disease; It is a hereditary disorder of the brain's electrical activity.

5.1. LOKUS CFA37 AND ADAM23: SYNAPSE STABILIZER

The latest research (e.g. Berner University and international cooperation) has focused on chromosome 37 (CFA37). In this area, the **ADAM23 gene has been identified**, which is the single most important factor in epilepsy in Belgian Shepherds.

- **Mechanism:** ADAM23 produces a protein that "anchors" the connections between neurons. It regulates the activity of ion channels, which in turn control the electrical charge of the nerve cell.
- **Risk allele:** If a dog has a mutation in this gene, anchoring fails. This leads to overstimulation of the nervous system, which erupts as an epileptic seizure.

5.2. CFA14 AND RAPGEF5: ADDING COMPLEXITY

Research has shown that CFA37 does not explain all cases. The RAPGEF5 located on chromosome 14 has been identified as another significant risk factor.

- **Interaction:** If a dog carries a risk allele in both loci (CFA37 and CFA14), its statistical risk of developing the disease is many times higher than a dog with a defect in only one or not both. This explains why some "carriers" stay healthy and others get sick – it's all about the sum of genes

5.3. INTERPRETATION OF TEST RESULTS: CLEAN, CARRIER OR SICK?

The epilepsy test gives the dog a status that must be understood correctly so that the breeding base is not reduced too much.

Status	Genotype	Description	Breeding use
Pure (N/N)	Homozygous normal	Does not carry an identified risk allele.	Recommended for all partners.
Plaintiff (N/Epi)	Heterozygous	**"In between."** The dog itself is usually healthy, but carries one risk allele.	**Only with an N/N partner.**

Status	Genotype	Description	Breeding use
High Risk (Epi/Epi)	Homozygous risk	The carrier is two risk alleles. Very high probability of getting sick.	Not recommended for breeding.

IMPORTANT: A carrier dog (N/Epi) is not automatically sick. However, it is a genetic risk holder. If mated with another N/Epi dog, statistically 25% of the puppies will have Epi/Epi status, which is ethically unsustainable.

5.4. PHYSIOLOGY AND DIAGNOSTICS OF SEIZURES

What happens in a dog's brain during a seizure?

1. **Focal onset:** The seizure begins with a small electrical "short circuit" in a specific area of the brain (e.g., facial twitching).
2. **Generalization:** An electrical storm spreads to the entire cerebral cortex. The dog loses consciousness and convulses (Grand Mal).
3. **Post-icttal phase:** After an attack, the brain's neurotransmitter stores are empty. The dog may be confused, blind, or exhausted for hours.

5.5. DIAGNOSTIC PROTOCOL IN FINLAND

Since the epilepsy test is not yet "official" in all registries, the diagnosis is often based on the exclusion:

- **Blood tests:** Checking of liver, kidney and electrolyte values (exclusion of metabolic causes).
- **MRI and cerebrospinal fluid sample:** Exclusion of tumors or inflammations.
- **Genetic test:** Used as a predictive tool and to support diagnosis.

5.6. EPILEPSY AND BREEDING STRATEGY (RISK MANAGEMENT)

This section introduces **"Controlled Progress"**:

- If you have an excellent working dog in your line that turns out to be a carrier (N/Epi), don't rush. Find a genetically distant N/N partner for it.
- Test the puppies. Choose a N/N individual with the good qualities of his mother/sire. In this way, you have "cleaned" the line in one generation without losing valuable work heritage.

Chapter 5 summary:

Idiopathic epilepsy is a polygenic disease that focuses on the ADAM23 and RAPGEF5 genes. Testing allows us to identify dogs "in between" and prevent the birth of high-risk (Epi/Epi) puppies. Breeding choices must be made based on mathematics and physiology, not fear.

CHAPTER 6: HEREDITARY ATAXIAS AND OTHER NEUROLOGICAL DISORDERS

Whereas epilepsy is an "electrical storm" of the brain, ataxia is an "architectural degeneration". Spongy Degeneration with Cerebellar Ataxia (SDCA) in Belgian Shepherds is a drastic, early-onset disease that has been pinpointed to certain genetic defects.

6.1. SDCA1: POTASSIUM CHANNEL DYSFUNCTION

SDCA1 has been associated with a mutation *in the KCNJ10* gene. This gene is responsible for a protein that regulates the passage of potassium ions in the support cells (astrocytes) of the central nervous system.

- **Mechanism:** When potassium regulation fails, fluid and vacuoles (vacuoles) form around nerve cells, leading to brain tissue becoming "sponge-like" (spongiform degeneration).
- **Symptoms:** Typically begin at 5–8 weeks of age. The puppy is fumbling, it falls over and its movements are jerky.
- **Inheritance:** Autosomal recessive. This means that both parents must be carriers for a sick puppy to be born.

6.2. SDCA2: ATP METABOLISM ERROR

SDCA2 is often even more severe in its symptoms than SDCA1. It is caused by a mutation in the *ATP1B2* gene.

- **Mechanism:** The error interferes with the ATP pump, which is vital for the energy supply of nerve cells and the maintenance of electrical balance. This leads to rapid neuronal death, especially in the cerebellum.
- **The difference to SDCA1:** In SDCA2 puppies, symptoms can start as early as 4 weeks of age and may be accompanied by blindness or intention tremor.

6.3. TESTING AND BREEDING CHOICES: 100% AVOIDABLE

Unlike epilepsy discussed in Chapter 5, ataxia is a "black and white" disease. Since it is completely recessive, we can eliminate its risk from the population by one generation without pruning valuable dogs.

- **Carrier (N/SDCA):** The dog is completely healthy. It will never get ataxia because it has one healthy gene that is enough for normal functioning.

- **Breeding instructions:** The carrier can and often should be used if it is otherwise an excellent individual. However, it must **always** be paired with a tested clean (N/N) partner.
- **Objective:** No sick (SDCA/SDCA) puppies.

6.4. SENSORY NEUROPATHY AND OTHER RARE ABNORMALITIES

In addition to ataxia, other, less common neurological disorders have been identified in Belgian Shepherds:

1. **Sensory neuropathy:** A sensory impairment in which the dog does not feel pain in its limbs normally. This can lead to self-chewing (suicidal behavior).
2. **Behavioral genetic connections:** As you mentioned in your original book, a "sharp" nervous system is a breed trait. However, there are research indications that extreme sensitivity to sound or obsessive-compulsive tail-shopping may be linked to the same neurological pathways as mild epileptic disorders.

6.5. DIAGNOSTIC DISTINCTION: ATAXIA OR EPILEPSY?

It is critical that the breeder and the veterinarian know how to differentiate between the two:

- **Age:** Ataxia almost invariably begins at the age of less than 4 months. Idiopathic epilepsy usually begins between the ages of 1 and 5 years.
- **Seizures:** Epilepsy is paroxysmal (sometimes the dog is normal). Ataxia is continuous and progressive (the dog feels "drunk" all the time).

Chapter 6 summary: Ataxia (SDCA1/2) is a severe cerebellar disease that is completely controllable with genetic testing. Due to its recessive nature, it is safe to use carriers as long as the partner is clean. This figure underscores that neurological health is the sum of many factors, and the ataxia test is a basic tool for any responsible educator.

CHAPTER 7: ONCOLOGY – CANCER AND GENETIC PREDISPOSITION

Although neurological diseases are the most debated, statistically, cancer is one of the leading causes of death in Belgian Shepherds. The Belgian Shepherd is not just "one breed among others" in cancer statistics; Certain forms of cancer are many times more likely to occur in the breed compared to the dog population on average.

7.1. GASTRIC ADENOCARCINOMA: A SPECIFIC SCOURGE OF THE BREED

Gastric cancer is exceptionally common in Belgian Shepherds, especially Tervuerens and Groenendaels. Studies (e.g. *Lubke et al.*) show that the breed has a significant hereditary susceptibility to that disease.

- **Genetic background:** It is likely to be an autosomal dominant inheritance with low penetrance. This means that a dog can carry the predisposing gene without getting sick itself, but it will pass the susceptibility on to its offspring.
- **Mechanism:** Cancer originates in glandular cells in the lining of the stomach. Belgian Shepherds have been found to be associated with chronic gastric inflammatory conditions, which can act as "triggers" for cancer.
- **Diagnostics:** The challenge is to be asymptomatic in the early stages. By the time a dog starts vomiting or losing weight, the cancer has often already spread.

7.2. HEMANGIOSARCOMA: THE SILENT KILLER OF BLOOD VESSELS

Hemangiosarcoma is a very aggressive cancer of the vascular wall that is often found in the spleen or heart in Belgian Shepherds.

- **Pathophysiology:** The tumour is fragile and rich in blood. It can rupture suddenly, leading to internal bleeding and a state of shock.
- **Genetic link:** Studies suggest that certain genes that regulate the immune system (such as the DLA regions mentioned earlier) may be involved in your dog's body's ability to recognise and destroy incipient tumour cells.

7.3. LYMPHOMA AND THE ROLE OF THE IMMUNE SYSTEM

Lymphoma is a cancer of the lymphatic system that often spreads to the lymph nodes, spleen and liver.

- **Association with diversity:** There are indications that populations with high **gCOI%** and narrow genetic diversity are at increased risk of lymphoma. When the immune system is genetically "one-sided," it is not able to respond as effectively to mutated cells.

7.4. CANCER AND EPIGENETICS: CAN WE INFLUENCE THE RISK?

As we learned in Chapter 4, genes are not the whole truth. The risk of cancer is affected by:

- **Carcinogens:** Pesticides, pollutants, and certain chemicals can damage DNA. In the case of a Belgian Shepherd who already has a genetic predisposition, avoiding these is critical.
- **Inflammation:** Chronic low-grade inflammation (e.g., an untreated allergy or intestinal disorder) creates an environment in which cancer cells thrive.

7.5. BREEDING SOLUTIONS FOR CANCER RISK MANAGEMENT

Since there are no direct genetic tests for many cancers yet, breeding is based on **family history and risk diversification**:

1. **Transparency:** Breeders must report cancer cases to identify the risks of the lines.
2. **Lifespan analysis:** In breeding, prefer lines where dogs live healthy to an advanced age (over 10–12 years).
3. **gCOI minimization:** The more diverse a litter is genetically, the better "tools" its immune system has to fight cancer.

Chapter 7 Summary: Cancer is a complex interaction between the genome, the immune system, and the environment. Gastric cancer in the Belgian Shepherd is a clear indication of the genetic load within the breed. Promoting health requires not only awareness, but also active choices to increase genetic diversity and reduce the chemical load on the environment.

CHAPTER 8: MUSCULOSKELETAL SYSTEM – STRUCTURE, ENDURANCE AND GENETIC INDICES

The Belgian Shepherd is an athlete whose physique has been honed for speed and agility. Bone health is not just the "absence of defects", but it is the foundation that allows the nervous system and the musculature to work together seamlessly. In this chapter, we'll analyze how hereditary factors affect a dog's mechanical endurance.

8.1. JOINT DYSPLASIA: HIPS (HD) AND ELBOWS (ED)

Although hip and elbow dysplasia are polygenic and are also affected by the environment during growth, their genetic background is undeniable.

- **BLUP indices vs. Phenotype:** The BLUP index used in Finland is a more efficient breeding tool than the imaging result of an individual alone (e.g. Phenotype). "A-hips"). The index takes into account all relatives.
    - **Fact:** A dog with B-hips but whose entire family is A-hips is more valuable in breeding terms than an A-hip individual whose siblings have D-hips.
- **Gene connectivity:** It is important to note that hip health should not be pursued at the expense of genetic diversity. If we prune the line based only on hips, we may inadvertently narrow the immune system (DLA) variability.

8.2. BACK HEALTH: LTV, SP, AND VA

Finland has been a pioneer in the official imaging of back changes. The health of the Belgian Shepherd's back is critical, because in protection and agility hobbies, enormous forces are exerted on the back.

1. **LTV (Lumbar Sacrum Change):** This is a congenital vertebral deformity at the transition point.
    - **LTV1–LTV4:** Changes range from slight asymmetry to complete vertebral change.
    - **Meaning:** LTV can predispose to early wear and tear of the lumbar-sacral interval (cauda equina syndrome), leading to pain and impaired control of the hind legs.
2. **SP (Spondylosis):** A degenerative disease of the spine in which bone bridges form between the vertebrae. Although it is partly related to aging, a tendency to early spondylosis has been observed in Belgian Shepherds in certain lines.

3. **VA (Vertebral malformations):** For example, semi-vertebrae (hemivertebrae), which are hereditary and can cause compression conditions in the spinal cord.

8.3. SKELETAL AND NERVOUS SYSTEM INTERACTIONS

In Chapter 3, we discussed the nervous system, but it should be remembered that the skeleton is the protective shell of the nervous system.

- **Nerve compression (stenosis):** If the dog has structural stenosis in the spinal canal (e.g. As a result of LTV), nerve messages do not flow cleanly. This can manifest as "lameness" for which no cause can be found in the limbs, or even behavioral disorders due to pain.
- **Proprioception:** In order for a Belgian Shepherd to perform complex jumps, its brain needs to know exactly where its limbs are. Skeletal misalignments interfere with this feedback.

8.4. GROWTH TIME AND EPIGENETICS IN SKELETAL DEVELOPMENT

Genes provide the framework, but the environment finalizes the end result.

- **Nutrition:** Too rapid growth (too much energy or an unbalanced calcium/phosphorus ratio) can trigger a genetic predisposition to dysplasia.
- **Exercise:** Controlled exercise on uneven terrain strengthens the supporting muscles, which protects the joints. Jumping too early and violently, on the other hand, damages the growth plates.

8.5. BREEDING CHOICES IN TERMS OF STRUCTURE

This section highlights **the big picture**:

- Do not use a dog with several serious back changes (e.g. LTV4 + SP2), even if it is otherwise the top individual of the breed.
- Prefer combinations with "complementary" backs. If the bitch has LTV1 (asymmetry), choose a male who is LTV0 (pure).
- **gCOI linkage:** The higher the inbreeding rate, the more likely structural weaknesses are to accumulate and be inherited more strongly.

Chapter 8 summary: The musculoskeletal system of the Belgian Shepherd is a complex entity in which hereditary indices (BLUP) and back imaging (LTV, SP) are key tools. Structural health is a prerequisite for a dog to be able to utilize its wonderful nervous system and instincts without pain. The breeder must look beyond the surface and understand how changes in the skeleton affect the dog's entire physiology.

CHAPTER 9: DIET, ENVIRONMENT, AND EPIGENETICS – GENE REGULATION IN EVERYDAY LIFE

While genetics give the dog the "blueprints", the environment and nutrition act as "foremen" who decide which guidelines to follow. The Belgian Shepherd, which has a sensitive neurological and immunological system, reacts more strongly to changes in the environment than many other breeds. In this chapter, we'll look at how we can optimize your dog's health at the cellular level.

9.1. EPIGENETICS: TURNING GENES ON AND OFF

As discussed in Chapter 4, epigenetics refers to chemical changes that occur on top of a DNA chain that regulate the activity of genes without altering the code itself.

- **Methylation and acetylation:** These are the ways in which the cell "attenuates" or "amplifies" certain genes. For example, cancer-preventing genes can be extinguished due to an unfavorable environment.
- **Fetal programming:** Stress or lack of nutrition experienced by the mother during pregnancy leaves an epigenetic imprint on the puppies. This can manifest itself later in life in more sensitive reactions to stress or a lower threshold for neurological disorders.

9.2. NUTRITION AS NEUROLOGICAL SUPPORT: MCT OILS AND EPILEPSY

One of the most significant areas of research in the treatment of epilepsy in Belgian Shepherds is **ketogenic nutrition** and especially medium-chain fatty acids (MCTs).

- **Mechanism of MCT oil:** Unlike regular fats, MCT fats (especially C8 and C10) are converted into ketones in the liver, which cross the blood-brain barrier. They provide the brain with an alternative source of energy that stabilizes the membranes of nerve cells.
- **Research evidence:** Several studies show that MCT supplementation can reduce seizure frequency and improve a dog's cognitive performance (reducing "brain fog").
- **Antioxidants:** Vitamin E, selenium, and omega-3 fatty acids (EPA/DHA) reduce neuroinflammation in the brain, which is often the underlying cause of epilepsy and cognitive decline.

9.3. STRESS BIOCHEMISTRY AND CORTISOL MANAGEMENT

A high level of alertness in a Belgian Shepherd often means a constantly elevated cortisol level. Cortisol is an essential hormone, but it is destructive if it is long-term.

- **Cortisol and thresholds:** Constant stress lowers the threshold for electrical discharges (seizures) and weakens the immune system's ability to recognize cancer cells.
- **The importance of recovery:** Educators and practitioners must understand the importance of the parasympathetic nervous system. Sleep is the brain's "cleansing mechanism" (glymphatic system) that removes waste products. Sleep deprivation is one of the most well-known triggers of idiopathic epilepsy.

9.4. CHEMICAL LOAD AND ENVIRONMENTAL CARCINOGENS

Gastric cancer and hemangiosarcoma, discussed in Chapter 7, are often linked to environmental stimuli.

- **Home environment:** Harsh cleaning agents, pesticides (such as lawn fertilizers), and even certain plastic softeners (phthalates) can act as endocrine disruptors or carcinogens.
- **Recommendation: In** the case of Belgian Shepherds who have been found to have a hereditary susceptibility to cell changes, minimising chemical exposure is part of responsible ownership.

9.5. MICROBIOME – SECOND BRAIN

The gut-brain axis, or microbiome, is directly connected to the brain.

- **Communication:** Gut bacteria produce a significant portion of your dog's neurotransmitters, such as serotonin and GABA.
- **Inflammation and behavior:** An unbalanced microbiome (dysbiosis) can increase systemic inflammation, which is reflected in both allergies and neurological instability.

Chapter 9 summary: While we can't change a dog's basic DNA, we can have a significant impact on how genes are read. Proper nutrition (such as MCT oils), stress management, reducing the chemical load and supporting gut health are active ways to postpone or even prevent the onset of hereditary diseases. Health is a dynamic space that is built every day.

CHAPTER 10: A FINNISH RESEARCH PROJECT – THE POWER OF DATA AND OPENNESS

Finland is an exceptional country for canine health research. A comprehensive registry system (KoiraNet), high-quality veterinary medicine and an exceptionally active community of enthusiasts have created an environment in which genetics research can progress faster than anywhere else. The Belgian Shepherd has been one of the focus breeds of Finnish research, and the results will benefit the breed worldwide.

10.1. NATIONAL EPI PROJECT AND BLOOD SAMPLE BANK

At the heart of the Finnish research is the canine genetic research group led by Professor Hannes Lohi. The study of epilepsy in Belgian shepherds has relied heavily on the activity of Finnish owners.

- **Biobank:** Thousands of Finnish Belgian Shepherds have donated a blood sample for testing. This data has enabled **the identification of** the CFA37 (ADAM23) **and** CFA14 loci mentioned earlier.
- **Importance of control data:** The study does not only need sick dogs. In Finland, we have succeeded in collecting an exceptionally large amount of control data: healthy Belgian Shepherd Dogs over 10 years of age. Comparing their genome to epileptics has revealed the protective factors that keep dogs healthy despite risk alleles.

10.2. CULTURE OF OPENNESS: KOIRANET AND HEALTH STATEMENTS

The Finnish Kennel Club's breeding information system is internationally unique.

- **Phenotype monitoring:** KoiraNet allows you to monitor hip, elbow and back changes in real time. The breeder can see at a glance the predisposition of the male line to spondylosis or LTV changes, for example.
- **Voluntary notifications:** In Finland, there is a strong tradition of reporting diagnosed illnesses, such as epilepsy or ataxia, to public lists. This openness is the breed's biggest safety net. It removes blame and replaces it with information.

10.3. UTILISATION OF GCOI DATA IN FINNISH BREEDING

A new generation of Finnish breeders have started to use genomic SNP panels (such as MyDogDNA).

- **Population status:** The average gCOI% **of the Finnish Belgian Shepherd population** gives us an idea of how inbred the population really is.
- **Simulation of combinations:** Modern technology makes it possible to test the gCOI compatibility of a female and a male before mating. We can choose a combination that maximizes immune system (DLA) diversity and minimizes neurological risks.

10.4. FROM RESEARCH TO THE PEVISA PROGRAMME

To ensure that research data does not remain only in laboratories, it must be implemented in the rules.

- **PEVISA (Prevention of Hereditary Defects and Diseases):** In Finland, strict requirements have been set for the breed regarding imaging results.
- **Vision for the future:** The goal is for epilepsy risk markers (ADAM23/RAPGEF5) and ataxia tests to become part of the official PEVISA program. This would ensure that no high-risk litter would be registered without the risk being acknowledged and controlled.

10.5. HOW CAN THE OWNER PARTICIPATE?

This goal is achieved by inviting the reader to participate in the work of science.

1. **Blood sample donation:** Each sample is a piece in a large puzzle.
2. **Health Surveys:** Behavioral data and information about a dog's lifespan are just as important as DNA.
3. **Honesty:** Reporting illness is the greatest service an owner can do to the breed.

Summary of Chapter 10: Finnish research has shown that when science and amateurs meet, results are produced. Blood sample banks, KoiraNet data and genomic tests are tools that can be used to defeat epilepsy and ataxia. Openness is the force that turns an individual dog's illness into a survival strategy for the entire breed.

UNIT 11: BREEDING CHOICES AND MATH – COI% VS. GCOI%

Traditionally, dog breeding has been based on analyzing pedigrees and looking for combinations where the common ancestors are as far away as possible. However, modern genomics has shown that the pedigree is only a rough estimate of reality. In a breed like the Belgian Shepherd, where the population is closed and there are few founding dogs, the traditional count can lead to dangerous misconceptions.

11.1. CONVENTIONAL INBREEDING COEFFICIENT (COI) AND ITS BLIND SPOTS

The COI (Coefficient of Inbreeding) is calculated using formulas that predict how much of a puppy's genome is homozygous (identical inherited from both parents).

- **Generational depth:** 5 generations of COI often show zero, but 10 or 20 generations reveal that all dogs revert to the same ancestors.
- **Mendelian coincidence:** The pedigree assumes that each ancestor passes on exactly 50% of their genes. In reality, siblings can inherit very different amounts of common genes. On paper, their COI is the same, but the difference in genetics can be huge.

11.2. GENETIC INBREEDING (GCOI): WHAT DOES DNA TELL US?

gCOI is measured by analyzing the entire genome of the dog using SNP markers. It does not guess the probabilities, but directly calculates how much of the dog's genome is actually identical.

- **Accumulation of homozygosity (ROH):** gCOI reveals "Runs of Homozygosity". The longer these periods are, the closer the parents have been.
- **Why is gCOI important in epilepsy?** If a dog's gCOI is high (e.g., >15%), it means that much of their genome is "locked." If even a single risk allele (such as ADAM23) is located in this locked area, it is inherited as homozygous, which increases the risk of disease many times over.

11.3. BREAKING THE "STRANGE MALE" ILLUSION

One of the most common mistakes is to bring a male from a completely different line or country into breeding, believing that he will bring "new blood".

- **Genetic overlap:** Even if the pedigree does not have the same names for five generations, a male can carry the exact same haplotypes (gene packages) as a female.
- **True outbreeding:** the gCOI measurement reveals whether dogs are actually genetically different. Sometimes a "lined" combination can be genetically more diverse than a poorly designed "outbred".

11.4. SAFEGUARDING DLA DIVERSITY

As previously stated, DLA genes in the immune system are vital.

- **Diversification:** The goal of breeding selection should be a combination in which the parents have different DLA haplotypes. This maximizes the puppies' ability to resist infections and prevents autoimmune diseases.
- **Switching imbalance:** If we select a dog based only on a low COI number, we may inadvertently lose rare DLA types if we do not use genomic information.

11.5. PRACTICAL TOOL: GENOMIC PAIRING SIMULATION

Breeding tool of the future:

1. **SNP testing of both parents.**
2. **Virtual Mating:** The software calculates the predicted gCOI and DLA distribution for the future litter.
3. **Risk assessment:** The program warns if the combination produces a high probability of homozygosity in critical areas (such as epilepsy loci).

Summary of Chapter 11: Mathematics is a breeder's best friend, as long as the correct numbers are used. A traditional COI is a good indicative tool, but gCOI is what determines a dog's true health and vitality. The goal is not zero inbreeding, but controlled homozygosity that secures the characteristics of the breed but avoids genetic collapse.

CHAPTER 12: BREEDING STRATEGY AND EXPANSION OF THE GENE POOL – FORGOTTEN RESOURCES

In order for the Belgian Shepherd to remain a viable working dog, we cannot rely on just a small elite group of known male lines. The more we weed out the population on health grounds (such as due to epilepsy or ataxia stasis), the more important it becomes to find new, replacement lines. In this chapter, we will look at "latent" diversity and its importance in saving the breed.

12.1. LOW-OCCUPANCY MALES: POPULATION "SLEEPING" POTENTIAL

Most Belgian Shepherd males never end up continuing their lineage. Although strict pruning is part of breeding, we have pruned too effectively.

- **Guardians of the gene reserve:** Many males who do not have the highest race results or show titles carry rare haplotypes (gene combinations) that have disappeared from "fashion males".
- **Re-evaluation of criteria:** Breeding value is not only in the merits of the individual, but in its ability to bring such variation to the population that lowers the gCOI level of the entire breed.
- **Strategy:** Encourage breeders to look for healthy, good-natured males of the right type, who represent lesser-used families. One litter with such a male may be genetically more valuable than the tenth litter with the most popular champion.

12.2. EXTENSION OF THE DEFINITION OF 'WORKING DOG'

The Belgian Shepherd is a working dog, but the narrow focus only on Finnish Championship level competition dogs leads to a genetic dead end.

- **Everyday heroes:** A healthy, balanced and functional hobby dog that functions in the everyday life of its owner without problems is genetically valuable. If its nervous system is stable (GABA balance in order, as we learned in Chapter 3), it is a valuable addition to breeding, even if it does not have medal positions.

- **Risk diversification:** By using a wider variety of dogs, we don't put all our eggs in one basket. If a popular male later turns out to be a carrier of the disease, the damage to the population will be massive. If we use ten different males, the damage is limited.

12.3. SPERM BANKS AND HISTORICAL DNA

Frozen sperm is a time machine with which we can restore lost diversity.

- **Time jump into the past:** By using sperm from a healthy male who lived 10 to 20 years ago, we can restore to the population variation that has been eliminated in the intervening generations.
- **National preparedness:** The book proposes a strategic sperm bank, where samples of genetically rare but breed-specific individuals are collected before their lines are extinguished.

12.4. INTERVARIETY BREEDING

Although the Belgian Shepherd variants (Groenendael, Tervueren, Malinois, Laekenois) are isolated from each other, they are genetically the same breed.

- **Lowering FST values:** By crossing variants with each other in a controlled manner (e.g., short-haired and long-haired), we can introduce completely new DLA haplotypes into a closed population.
- **Example:** The risk of gastric cancer in the Tervueren population could possibly be diluted by introducing the Malinois genome, where the disease is less common.

12.5. TOOL FOR FUTURE BREEDING SELECTION: DIVERSITY SCORE

Towards the end of the book, we introduce the "Diversity Score", which helps the breeder choose a partner:

1. **gCOI calculation:** The goal is to calculate the gCOI value of the litter in relation to the breed average.
2. **Matching epilepsy and ataxia statuses:** Ensuring that no two carriers (N/Epi or N/SDCA) are ever combined.
3. **DLA compatibility:** Choose a pair with the most diverse immune system genes.
4. **Rarity index:** Preference is given to the male with the fewest offspring in the population.

Summary of Chapter 12: Expanding the breeding base is not a compromise on quality, but an assurance of the future. By using low-occupancy males, utilizing sperm banks, and being open to variant crossbreeding, we can dismantle the genetic bottlenecks that predispose the breed to disease. The courage to choose differently from the mainstream is the most important tool of a responsible educator.

CHAPTER 13: SUMMARY AND ETHICAL GUIDELINES FOR BREEDING – VISION 2035

We have taken a journey through the biology, history and genetics of the Belgian Shepherd. We have seen how cell-level communication errors (ADAM23) can lead to severe epilepsy and how a narrow gene pool (gCOI%) predisposes a race to cancer and immune system disorders. But we have also seen that we have more tools than ever before to change this direction.

13.1. SYNTHESIS OF KNOWLEDGE AND INTUITION

Modern refining isn't just Excel spreadsheets or just intuition; it's their seamless union.

- **Science provides a framework:** It tells us who carries ataxia or who is genetically too close to the other.
- **The breeder's eye gives the content:** Only the breeder can assess the dog's actual willingness to work, the structure of the nerves and its "Belgian character", which is not yet fully captured by any algorithm.
- **Ethical choice:** If science shows a risk (e.g. Epi/Epi status), an ethical breeder dares to give up even a fine individual in the name of the overall interest of the breed.

13.2. FROM SHAME TO OPENNESS: A NEW OPERATING CULTURE

One of the most important messages of the book is to break the culture of silence.

- **Illness is not a failure:** Genes are randomized in a way that no one can fully control. A sick dog in the line does not indicate a bad breeder, but hiding the illness does.
- **Cooperation across borders:** The Belgian Shepherd is a global breed. Finnish openness (KoiraNet and research cooperation) acts as a beacon for other countries. The goal is a global, open database where gCOI and health information travel with the dog.

13.3. VISION 2035: A HEALTHIER BELGIAN SHEPHERD

What will the race look like in ten years if we follow the teachings in this book?

1. **Epilepsy Management:** Idiopathic epilepsy has not disappeared, but its prevalence has been halved because we no longer consciously produce high-risk (Epi/Epi) combinations.

2. **Genetic recovery:** The breed's average gCOI level has reversed due to low utilization males and controlled variant crossbreeding.
3. **Durable structure:** Back changes (LTV) are routinely taken into account in breeding, and hobby dogs live longer without chronic pain.
4. **Conscious ownership:** Owners understand the importance of epigenetics and support their dogs' health with nutrition (MCT oils) and the right load.

13.4. BREEDER'S RESPONSIBILITY AND LEGACY

Each litter is a message that we send to the future. We have a responsibility not only to current dog owners, but also to the history of the breed.

- **Breeding is a loan:** We do not own the breed, but we are the owners of its genetic heritage.
- **Courage to change:** Science is constantly evolving. What was true ten years ago may be outdated today. A responsible operator is ready to update its thinking in the face of new information.

13.5. FINAL WORDS

This work was born out of love for the Belgian Shepherd – its intelligence, strength and loyalty. Diseases are the price we have paid for specialization, but they do not define the end of the race. They define a new beginning: an era in which we use our intellect to protect the dog that has always protected us.

Chapter 13 Summary: The book's conclusion emphasizes that health is a choice. We now have access to data (gCOI, epilepsy tests, back scans), medicine (neurobiology, oncology) and an ethical framework. The future of the Belgian Shepherd is bright if we dare to be honest, open and scientifically aware.

CONCLUSION OF THE BOOK: KNOWLEDGE IS LOVE, RESPONSIBILITY IS THE FUTURE

We have arrived at the last pages of this book. Our journey has taken us deep into the essence of the Belgian Shepherd – from the rugged slopes of 19th-century shepherds to today's high-tech laboratories, where DNA chains reveal their secrets.

This book was not born out of a desire to highlight the problems of our breed, but out of a passion to equip every breeder, hobbyist and owner with the knowledge that makes these problems manageable.

A LEGACY WE CHERISH

The Belgian Shepherd is more than a breed; It is a living monument to the cooperation between man and dog. Its electric intelligence, lightning-fast reactions, and unwavering loyalty are features we love. As we have learned, it is these traits that make the breed physiologically unique and at the same time vulnerable.

We cannot remove a dog's inheritance of its sensitivity without losing its soul. But we can—and must—eliminate the genetic defects that turn this sensitivity into a disease. Idiopathic epilepsy, ataxia and susceptibility to cancer are not characteristics of the race; They are the consequences of choices and coincidences in history that we now have the power to correct.

A NEW ERA: THE POWER OF OPENNESS

The biggest obstacle to the health of the breed has never been a lack of information, but silence. A sick dog has been seen as a failure, when in reality it is only an indication of the complexity of life. With this work, I hope that we will move from a culture of shame **to an era of openness once and for all**.

When we report cases of illness, when we test our dogs genomically and when we share information across borders, we do not weaken the breed. On the contrary, we make it invincible. Information is the tool we use to break the cycle of disease and ensure that future generations can enjoy healthy and vigorous working dogs.

EDUCATOR'S ETHICAL LIGHTHOUSE

Every litter is a promise. It is a promise to the new owner that we have done everything we can to give this life the best possible starting point. It is a promise to the breed that we have acted as enrichers, not eliminators, of its genetic reserve.

With the lessons learned in this book, the educator now has a modern lighthouse in his hands:

- **gCOI%** guides us past the pitfalls of homozygosity.
- **DLA diversity** ensures a strong immune system.
- **Genetic tests (CFA37/14 and SDCA)** remove dark spots from hereditary diseases.

FINAL WORD

In the end, however, it is about something bigger than just science. It's all about the feeling when you look into your Belgian Shepherd's eyes and see centuries of history and anticipation of the future. We are the protectors of this wonderful breed. Our job is to make sure that in decades someone else will sit down, look at their own healthy and strong Belgian Shepherd and thank us for daring to choose knowledge, openness and responsibility.

Health is not the end point. It is a journey that we walk together.

APPENDICES AND TOOLS (DRAFT)

ANNEX 1: GENETIC AND NEUROLOGICAL VOCABULARY

This vocabulary helps you understand research reports and the results of genetic tests.

- **ADAM23/RAPGEF5:** Key loci (gene regions) associated with hereditary epilepsy in Belgian Shepherds.
- **Allele:** An alternative form of a gene. A dog inherits one allele from each of its parents.
- **DLA haplotype:** A combination of genes in the immune system. High DLA diversity protects against autoimmune diseases.
- **Epigenetics:** A research mechanism that explains how the environment (food, stress) turns genes on or off without altering the DNA code itself.
- **Fst value:** A measure of the genetic distance between populations (e.g. variants).
- **gCOI (Genomic Coefficient of Inbreeding): The** actual inbreeding rate measured by a DNA test. Tells the amount of homozygosity more accurately than pedigree.
- **Heterozygosity:** A situation in which a dog has inherited different alleles from its parents (e.g. N/Epi). This increases genetic diversity.
- **Homozygosity:** A situation in which a dog has inherited the same allele from both parents (e.g. Epi/Epi or N/N).
- **MCT (Medium-Chain Triglycerides): Medium-chain fatty** acids used as a dietary supplement to support the brain's energy metabolism in epilepsy.
- **Neuroinflammation:** A low-grade inflammatory condition of brain tissue that can lower the seizure threshold.
- **ROH (Runs of Homozygosity):** Long identical sequences in the DNA chain that reveal close kinship.
- **SNP (Single Nucleotide Polymorphism):** A change in a single base in DNA; used as a marker in genome-wide tests.

APPENDIX 2: BREEDER'S CHECKLIST – 10 STEPS TO A RESPONSIBLE LITTER

Use this list for each combination to minimize risk.

1. **Status check (Neurology):** Have both parents been tested for epilepsy (ADAM23/RAPGEF5) and ataxia (SDCA1/2)? *Rule: Never combine two carriers.*
2. **gCOI Analysis:** What is the Predicted gCOI Rate? Try to calculate the homozygosity of the litter in relation to the breed average.

3. **DLA Compatibility:** Choose a partner with different DLA haplotypes than your. This is an insurance for your immune health.
4. **Numerous ancestral review:** Is the male a low-occupancy individual? If the male is already a "Popular Sire", consider a brother or other relative to expand the gene pool.
5. **Back and skeletal indices:** Check the BLUP indices and official back statements (LTV, SP). Make sure that the same type of back changes do not accumulate in the combination.
6. **Lifespan analysis:** Find out the causes of death of parents and grandparents. Prefer lines with longevity (12+ years).
7. **Nervous system stability:** Assess temperament – does the dog have the ability to recover from stress? (Remember Chapter 3: The Importance of the Parasympathetic Nervous System).
8. **Genealogy and research openness:** Is the male owner also willing to share information about cases of illness in his family?
9. **Environmental program:** Plan the puppy's diet (epigenetics) and stress-free growth environment in advance.
10. **Future monitoring:** Commit to collecting data on emerging puppies and report any illnesses openly to research teams.

ANNEX 3: KEY BIBLIOGRAPHY (SELECTED WORKS)

Recommended further reading and scientific support.

- **Lohi, H. et al.:** *Genetics of canine idiopathic epilepsy.* (Nature/Science publications regarding ADAM23 and RAPGEF5).
- **Maudet, C. et al.:** *Genetic diversity and population structure of Belgian Shepherds.*
- **Berner University:** *SDCA1 and SDCA2 research reports on cerebellar ataxia.*
- **MyDogDNA / Wisdom Panel:** *Technical manuals for Genomic COI and DLA diversity.*