"Mendel's Puzzle"

Desired traits can be produced by direction.
by
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In one way or another technology has had a profound effect on our history. It has also contributed to our material progress and effected the evolution of our social attitudes and many of our public policies. Folklore has also played an important role by affecting how we think and what we believe. Combined, technology and folklore have both had a profound influence on the way we live and the breeding of purebred dogs. Over the past half-century there have been an endless number of changes and technological breakthroughs that have affected us. Many of these changes began when the science of genetics began to redefine what was important. History suggests that most of these changes occurred after World War II when human health problems such as polio and smallpox were still considered life-threatening diseases. As these new technologies began to address the old problems, they also began to improve the quality of our lives and what we considered important. Emphasis shifted from treatment protocols to the prevention of viral and parasitic diseases. By the end of the 1960's these new technologies had eradicated most of the diseases with new immunizations. Soon to follow would be the mechanisms necessary to control the other dreaded childhood diseases and some of the animal diseases that had persisted during the past several centuries.
While advancements to improve human life moved with remarkable speed, the same pace did not take place in the dog world. The scientific community ignored the faults of conformation and many of the defects common to most breeds because they were not considered worthy research projects. In retrospect, most of the accomplishments can be attributed to one monk who in the 1850's thought he had uncovered the answer to heredity.

MENDEL

Today, we know that the basis for this science began in the early 1790”s when a British farmer, T.A. Knight crossed a garden pea that had purple flowers with one that had only white flowers. Everyone expected that the two flower colors would blend and produce lavender flowers. To everyone's amazement they produced only purple flowers. Knight's experiment puzzled everyone for years. Then came the Austrian monk named Gregor Johann Mendel who showed a keen interest in science. In 1843, he entered the Augustinian Monastery in Old Brno where he lived as an ordained priest. In 1851, he became a member of the Natural Science Society. Membership in the society provided him the opportunity to

lecture about his experiments and the ideas he was developing. His wonderful discovery of the principles of heredity draws attention to the fact that one individual working with little outside help could carry out many historic experiments. Because his ideas were new and not well understood they were not accepted. His experiments (1856-1864) on the genetics of inheritance involved the principles of dominant and recessive traits. Mendel's famous lecture in 1865 was not published until 1866. His experiments led him to propose a new way to think about inheritance and how traits are passed down from one generation to the next. For example, he suggested that each parent equally contributes to the makeup of their offspring based on their own inheritance. It was this idea that departed from the popular thinking of the 1800's. Mendel enlightened the world about many things, which oftentimes are overlooked by breeders. One of his greatest discoveries was to prove that a desired trait can be produced by direction instead of by chance.

The Puzzle

What made Mendel's approach so significant can be found in the strength of his experimental design and his interest in qualitative analysis. He used both to produce his postulates about inheritance. What Mendel found ultimately explained Knights puzzle. Until his experiments were published there was no understanding of dominant and recessive traits and why they could appear and then disappear. For example, Mendel found that when tall plants were bred to short plants, only tall plants were produced. After years of experiments using mathematics to calculate the frequency with which traits would appear he concluded that tallness was dominant over shortness. He also furthered the notion that there was something that could produce a non-dominant trait, which could linger in the background. Later the world would call it a recessive gene. His efforts resulted in the discovery that each trait is produced by one or more particles ("factors") and that each offspring receives its genetic instructions for their own make-up directly from the particles of their parents. Mendel died on June 1, 1884 not knowing the significance of his discoveries. After his death, his writings, experiments and materials were stored in the school's library where they remained virtually unnoticed. His research, which was decades ahead of its time, would be ignored until they were duplicated and then cited by Carl Correns, Hugo de Vries and Eric von Tschermak in 1900. It is interesting that researchers in Germany and Holland would independently find and use Mendel's experiments to launch their own studies. What is more interesting is that they would discover that their results were very much like those Mendel had discovered forty years earlier.
Today, we know that what Mendel called the "factors" or "particles" of inheritance were actually the genes. He did not know that they were the structures contained within the chromosomes. That would come later. What he proved was that genes travel in pairs and that they seemed to be packaged in one of two distinct types or alleles. To better understand this idea and for the sake of convenience letters are used to represent the alleles. The lower case letters (b, w, l) represent the recessive alleles. The dominant alleles are represented by upper case letters (B, W, and L).
Mendel learned that if both of the alleles are different, they are said to be heterozygous (Ww) for the trait. If they are both the same, they are called homogenous (ww). It was this discovery that led Mendel to his "First Law" of genetics, which works for all animals. What is more interesting is that he developed his ideas using only the garden pea plants.

Mendel proved that genes do not blend together, instead they retain their individual character even when a recessive gene is present and masked by a dominant gene. It took from 1790 to 1866 before the solution to this puzzle was found. Today, we know that the breeders who do not understand Mendel's Law of Genetics will continue to think about the occurrence of defects and recessives traits using folklore rather then science.
Figure 1 represents Mendel's First Law, which involves dominant and recessive traits. Imagine that you have bred two black dogs. One is black because it carries two dominant genes for black (BB). The other is black because it carries one dominant gene for black and one recessive gene (Bb) for the recessive color liver, which sometimes is called chocolate.

Figure 1 Two-Black dogs that are carriers

	B	b
B	BB	Bb
b	Bb	bb

Notice that breeding two carriers does not improve a breeding program because the number of carriers is increased. Notice in Figure 2, what happens when a carrier (Bb) is bred to a dog that is dominant (BB) for its color. Carrier to a non-carrier breedings produce 50% carriers and 50% dominant for their color.

Figure 2 Carrier X Dominant

	B	b
B	BB	Bb
B	BB	Bb

In addition to color, breeders can also apply Mendel's Law to other traits such as coat length. In this regard, the reader should note that breed standards use different words to mean similar things. For example, the word for a normal coat in one standard is sometimes called short or smooth coat in another standard. The short or smooth coat is dominant over the recessive coat, which might be called long, fluffy, feather or powder puff. Since Mendel's first law applies to many traits, let's take as our next example coat length since it can easily be seen and appreciated. In Figure 3, a long coat (ll) is bred to a short coat (Ll) that is a carrier for the recessive long coat. Notice that the recessive gene (l) is retained in every puppy.

Figure 3. Long Coat X Normal Coat

	L	I
I	LI	II
I	LI	II

Now notice in Figure 4 what happens when two carriers for the recessive coat are bred.

Figure 4. Normal Coat (carrier) X Normal Coat (carrier)

	L	I
L	LL	LI
I	LI	II

The breeding of two carriers will produce carriers in 75% of the offspring. This same principle was illustrated in Figure 1 for color.
The problem for most breeders is that they do not know if their dogs are carriers for recessive traits and many times, the traits in the puppies can be confusing if they do not think about Mendel's First Law of Genetics. For example, in Figure 4, suppose that only two pups were born instead of four, they could both have been two short coats (normal or smooth) or depending on the breed, they might both have long, shaggy, feathered or powder puff coats. However, when just one pup occurs with a long coat or a recessive color the breeder will know that both parents were carriers. The ratios seen in these figures are the mathematical frequencies a breeder should expect if the breedings were repeated several times. Breeders can learn about their pedigrees and the carriers by keeping a record of what they produce. Breeders will sometimes over look the obvious unless they remember that a recessive trait can remain in the background for several generations. A quick glance at the AKC breed standards show that many breeds have coat and pigment faults. To avoid them, a breeder must develop a record system that captures the traits produced in each generation. Mendel's experiments demonstrated that breeders could solve many of their problems that puzzle others if they keep records. Figures 1 and 4 illustrate how breeders can be led to believe that both parents were not carriers. The point here is this. When just one pup occurs with a long coat or a recessive color the breeder will know that both parents were carriers. Keeping records of each breeding on a Symbol pedigree helps to piece together the puzzle of what traits lay hidden in their pedigrees. For more information about how to use the Symbols pedigree and the technique for breeding the better dogs use the website below or the references listed.

References:
Battaglia, C. L. - Genetics - Breeding Better Dogs, BEI Publications, Atlanta Ga., 1999.
Bell, Jerold, "Developing a Healthy Breeding Program", National Parent Club Canine Health Conference, AKC Canine Health Foundation, St. Louis MO. October 15-17, 1999.
Hutt, Fred, Genetics for Dog Breeders, WH Freeman Co., San Francisco, CA, 1979
Willis, Malcolm, ”Breeding Better Dogs "(Key Note Address) National Parent Club Canine Health Conference, AKC Canine Health Foundation, St. Louis, MO. October 15-17 1999.

Willis, Malcolm, Genetics of the Dog, Howell Book House, New York, New York, 1989
Willis, Malcomb, "Breeding Dogs" Canine Health Conference, AKC Canine health Conference, Oct. 15-17, 1999. St. Louis, MO.
Willis, Malcomb, "The Road Ahead", AKC Gazette, August 2000, Vol. 117, number 8, p-47.

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