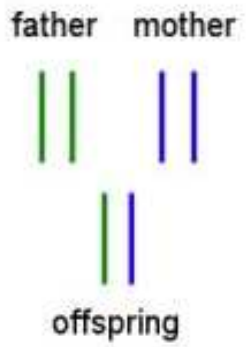
Color Inheritance in the Brittany

*This is a simplified tutorial on how genetic inheritance works. It is not intended to delve deeply into scientific theory, but rather be a beginner's guide to how a simple trait such as color is inherited.

All living beings are made up of genes. Genes have two halves, and when together, complete a set of instructions on how an organism will look, feel, act, etc. When an organism such as a dog reproduces they pass on half of each gene onto their offspring. The offspring will inherit one half of each gene from the father and one half from the mother. This means that for example if each gene had a letter and number assigned to it, such as A8 or W24, half of A8 would be inherited from the father and the other half from the mother, making a completed A8 gene. A common misconception is that we inherit half of our genes from one parent, and half from the other. For example, A8 would not come complete from the father and W24 complete from the mother. Both A8 and W24 would have half of each parent's copy of the gene.

In this image we can see how genes are inherited:



We can use this same image to illustrate the meaning of dominant and recessive. If we say this image shows the gene in charge of deciding what color a flower will be, and that green is dominant and blue recessive, we see that the father is green and the mother is blue. In the offspring the flower would also be green, but would carry the recessive for blue. What does this mean? Because half the gene is carrying the code for green, the flower has to be expressed as a green flower. The blue half of the gene is lying dormant. When that flower is bred there would be a 50% chance that their offspring would inherit the blue recessive, and if also inheriting another blue recessive from its other parent, would express the color blue.

In Brittanys there are several genes associated with color. Here we will look at the simplest expressions of the most recognizable genes.

The American Brittany comes in two colors, orange and liver. In addition to these two colors, there are two variations, roaning and tri-color. Let's start with the inheritance for orange and liver first.

In genetics, we use upper and lower case letters to show dominant and recessive genes. An uppercase letter means the gene is dominant (will always be expressed) and a lowercase means the gene is recessive (can be passed on but a dog must have inherited two copies of the gene for the trait to be expressed). So in the case of liver and orange, the liver is shown as a "B" and orange shown as a "b".

Example 1: A liver dog that has one orange parent will always be Bb. We breed that liver dog to an orange dog, bb. The orange dog is bb because they do not have a liver gene.

	b	b
B	Bb	Bb
b	bb	bb

In this example 50% of the puppies born would have a chance of being liver in color. 50% would have a chance of being orange. Every puppy would "carry" orange, but only a puppy born liver can "carry" liver. Liver is a dominant trait.

Example 2: A liver dog that has one parent which is orange is bred to another liver dog that also has one orange parent. Therefore we know both dogs are genetically Bb.

	B	b
B	BB	Bb
b	Bb	bb

In this example 75% of the puppies born would be liver in color but 25% of the puppies would be orange. Also, 50% would be Bb like their parents but 25% would be BB. A dog that is genetically BB would not look different than a Bb liver dog, but when bred would ONLY produce liver puppies regardless of the color of the other parent.

Roaning is also a dominant trait. You must have a roan parent to produce a roan puppy. It is important to note that while these are statistical averages when it comes to percentage of puppies born with a certain trait, even the largest litter is a statistically small number. The patterns of inheritance of liver and roan work exactly the same. Orange however is recessive, as is the tri-color gene. So let's look at that from a different angle.

Tri-color is not so much a color gene but rather a masking gene. What it does is it masks the liver gene B from being expressed in certain areas of the body; most commonly on cheeks, eyebrows, legs and under the tail. This allows the expression of b to show in those areas. For a dog to be a genetic tri-color they must have inherited TWO copies of the tri-color gene. So for the sake of argument we'll designate "t" as the tri-color expression and "T" as the absence of the gene.

Example 3: Neither parent is a tri-color. Both carry the gene however, but it is not known as neither dog has been bred before. Both dogs are Tt.

	T	t
T	TT	Tt
t	Tt	tt

In this example only 25% of the puppies will be genetic tri-colors, 75% will pass it on to offspring, and 25% will never pass it on. Now how do we know? We might not! Because the tri gene is a masking gene, if the puppies who have inherited two copies of the gene also happen to be orange in color, there is nothing to be expressed. The tri gene has no B gene to suppress. If the puppies born tt happen to be liver in color (either Bb or BB), you will see that they are tri-colored. This means 75% of an all-orange litter may carry or be a genetic tri-color and no one would be the wiser!

Example 4: One parent is a tri-colored dog. The other parent is a liver dog that does not carry the tri-gene.

	T	T
t	Tt	Tt
t	Tt	Tt

What a surprise to the breeder who was sure they would be getting tri-colored puppies! Not a single puppy born carried two copies of the tri gene. However, 100% of the puppies will pass on the tri gene to roughly 50% of their puppies.

With the tri gene, it can be passed down for unlimited generations and never see an expression of the trait if all dogs are orange in color (which is by far the more common coloration in the Brittany breed) or on the rare occasions a liver dog is used, the liver parent does not carry the tri gene.

So how common is a recessive gene like orange or tri-color? Well, it can be hard to say. With orange Brittanys we see a disproportionately large amount compared to the liver variety. Part of this has to do with the selection process, orange being more popular than liver, but some of it can be explained by pure chance. When two orange dogs are bred together, they will always produce only orange puppies. However, when two liver dogs are bred together, if both carry the orange recessive, they will also produce orange puppies along with liver.

Determining what percent of the Brittany population either is or carries the tri-color gene is much harder. Selection has very little influence on how widespread the gene is because for a breeder to know their dog is a genetic tri-color the dog must also be liver in color. Due to the much smaller population of liver dogs in our breed, it gives to reason that the majority of dogs who carry the gene are orange in color, and there is no selection process used to prevent passing

on the recessive gene. It is this author's educated guess that at least 75% of Brittanys carry the recessive for tri-color. We can come to that conclusion by simple math. If we start out with 4 dogs of each gene combination, TT, Tt, and tt; and breed each type once to another, in just one generation we go from 66% carrying or expressing tri-color to 71%. And with a greater population carrying the gene, the greater likelihood the gene will continue to increase its percentage of the population even without selection. Though the percentage of actual genetic tri-colors also decreases along with non-carriers in the first generation, it can be surmised that in subsequent generations that number will rise slightly due to an increase in carriers in the population.

	T	T
T	TT	TT
T	TT	TT

	T	T
T	TT	TT
t	Tt	Tt

	T	T
t	Tt	Tt
t	Tt	Tt

	T	t
t	Tt	tt
t	Tt	tt

	t	t
t	tt	tt
t	tt	tt

	T	t
T	TT	Tt
t	Tt	tt