

Basic Rabbit Color Genetics: A Step-by-Step Guide

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Since you're here, I suppose it is safe to presume that you would like to learn more about color genetics. If you're anything like me, you've already spent time sifting through websites, trying to understand a mumble jumble of letters and vocabulary, then closed the page in frustration. I understand. And that is why, if you'll stick with me, I will try to explain everything I know in the simplest way possible.

To start, the most important words to understand are gene and allele. I promise that these are the only two new vocabulary words you will need to learn! Basically, a gene describes the color of the coat. Alleles are "ingredients" that make up that color.

For example, AA is one way to write the agouti gene that I will tell you about later. It is made up of two capital A letters. Individually, each A is one ingredient. But when both A's come together, they make up the color of the coat that you see on your rabbit. If this makes sense so far, the rest will be a piece of cake! That is the hardest part to understand.

Now, in the study of basic genetics, you're working with the alphabet, letters A-E. Basically, it takes more than one gene to make up any given color. So every rabbit has a sequence of multiple genes in their body that tell their coat which color it will be. To make it easy for us to talk to each other about the genes a rabbit has, we label them with a letter. Consequently, there will be one A gene, one B gene, one C gene, etc.

Simplified, it will look something like this when we write it out: ABCDE

But remember what you just learned, that each gene is made up of two ingredients (alleles), so in reality, we will write it like this: AABBCCDDEE

Got it? If so, you've got it down! The only thing left to do is to match each letter with the color it produces.

A Series- Responsible for the Coat's Pattern

The A gene tells you whether the rabbit will be agouti, tan pattern, or self. So, there are only 3 possible alleles, or ingredients, in the A series.

A = agouti (chestnut, chinchilla, opal, squirrel, orange, fawn, etc.)

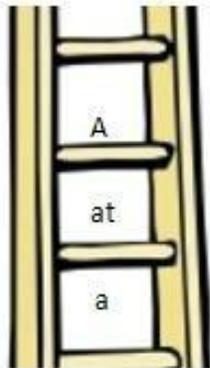
at = tan pattern (otters and martens)

a = self (any color that is not an agouti or tan pattern)

Remember again though that we need to put two alleles together to make a gene. For example, we could put two agouti alleles together to make AA. Or, we could put one tan pattern allele together with one self allele to make ata. Usually for that one, we would put parenthesis around the tan pattern allele just to make it easier to read: (at)a.

There is only one catch to mixing your ingredients. Have you heard the terms dominant and recessive before? The most dominant allele is the one that you will actually SEE on the coat and it is always written first in the gene sequence. The recessive allele is what the rabbit carries but you will not visibly see, it is just in their genetic make-up. For example, if the gene gives you Aa, the coat will be agouti because the capital A is written first. However, the rabbit is carrying self in their genetic code because the second allele is a lowercase a.

The next thing you might say is that someone has told you that a certain color cannot carry another color. How do you know whether or not a color can be carried? I've made it simple for you by listing the above alleles in their order of dominance. We can visualize this order of dominance in the form of a ladder too.



The most dominant allele is on the top rung, and the least dominant is on the bottom. Each allele can be paired with itself or anything below it. So your A series possibilities include:

AA	only agouti
A(at)	agouti carrying tan pattern
Aa	agouti carrying self
(at)(at)	true tan pattern
(at) a	tan pattern carrying self
aa	self

As you can see above, the allele that is dominant (written first in the pair) cannot be paired with another allele that is above it on the ladder. Therefore, you will notice that **agouti cannot be carried by any color** other than itself. Agouti is either the dominant allele that you will see on the rabbit or it is not present at all. Likewise, any color could carry self, but a self rabbit cannot carry any other A allele (except self) because it is the lowest rung on the ladder. So, a rabbit that is self cannot carry agouti or tan pattern.

B Series- The base color gene.

This will be, by far, your favorite gene! There are two simple alleles that make up the B series.

B = black

b = brown (chocolate)

So, what can our gene sequences be?

BB	black only
Bb	black carrying brown
bb	brown

Just to reiterate the ladder idea, black cannot be carried by brown because it is the most dominant allele (top of the ladder). Brown can be carried.

C Series

This is the most difficult series to understand, in my opinion. Let's just go ahead and jump in! I'll start, again, by listing the alleles in the order of dominance.

C = fully colored (contributes to all of the "normal" colors that are not listed below)

cchd = chinchilla dark (chinchilla, blue chinchilla)

cchl = chinchilla light (shaded) (sable point, blue point, siamese sable, seal, etc.)

ch = pointed white (or himi, in some breeds)

c = red-eyed-white (REW)

Just like the other gene series, the ladder is the best way to visualize different gene combinations. For this series, I will not list them all here since there are five alleles. That allows for many color possibilities! However, there are some very important things to know about this series, and I will mention those points below.

- The cchd, or chinchilla dark, gene is what contributes to a chinchilla-colored rabbit. However, the rabbit also must have the agouti allele (A) in order to be a correctly colored chinchilla. If the rabbit does not have an agouti gene, but has a self gene instead, it may cause a normal colored rabbit with a wrong eye color. These are usually called "self chin" because the agouti gene is absent (the rabbit appears as a self), but the rabbit carries the chinchilla dark gene.
- The chinchilla gene coupled with the tan pattern gene (at) is what causes marten coloration.
- The cchl, or chinchilla light, gene is a little bit misleading because of the name "chinchilla light". Usually, we call it the shaded gene because it accounts for shaded colors like sable point, siamese sable, and seal.
 - If the rabbit is sable point or siamese sable, it only has one cchl allele. The other allele **must** be either ch or c.

- If you're wondering why that is, it's because a double cchl gene is what causes seal.
- If you are breeding one shaded rabbit to a non-shaded rabbit in hopes of getting shaded carriers, it is important to note the two points above. Unless the shaded is a seal, it is not guaranteed to pass on the sable gene. You may get REW or pointed carriers instead.
- REW (cc) is an interesting gene! No matter what other A, B, D, or E alleles a REW carries, the cc will cancel them all out and make the rabbit white with red eyes. So, although the c allele is the most recessive in the C Series, it is actually very "dominating" when combined with another c.
 - Also, remember that since c is recessive (low on the ladder), it cannot carry any other C series alleles. Its partner must be another lowercase c. Therefore, a REW may be "hiding" agouti or chocolate with their white coat but a **REW can never hide or carry chinchilla or shaded** (other C gene alleles).

PHEW! Are you still with me? If you are, pat yourself on the back and grab a snack. Take a break and soak it all in. C is the most challenging series, so if you don't understand right away, that's okay. You can re-read it as many times as you like or just refer to the very basic allele list and clear your mind. It is no more difficult to manipulate than the other series, but it takes some time to figure out five different alleles, instead of one or two! Never fear though, you are almost done and the last two are easy!

D Series

The D Series is a pretty easy one, just like B. There are only two alleles.

D = dense (black and chocolate based colors)

d = dilute (blue and lilac based colors)

As you can see, the D Series is like a brother to the B series. The two are very closely related. In short, the B series chooses the base color of the rabbit (black or brown/chocolate). Then, the D Series comes in and decides whether that color will be fully expressed (dense) or diluted.

DD	dense only
Dd	dense carrying dilute
dd	dilute

E Series

Another one as easy as pie! Or at least we will make it that way here. There are a few extended or more challenging E alleles available, but most colors come from the two below:

E = extension (the color of the coat extends from base to tip)

e = non-extension (the body color is different from the point color)

Examples of full extension (E) colors would be black, blue, chocolate, lilac, chestnut agouti, opal, siamese sable, pointed white, etc. Non-extension colors include black tort, blue tort, sable point, frosty, etc.

EE	full extension
Ee	full extension carrying non-extension
ee	non-extension

That's it, the full gene series, from A-E! The only thing left is setting up all those genes in one gene sequence called the **genotype**, or genetic code of the rabbit. I know I promised only two vocabulary words, but this one will make you sound smart when you tell all your friends what you learned!

Remember earlier, when I told you AABBCCDDEE? Well, now tell me what it means!

To break it down, we have two agouti only alleles, so the rabbit has to be agouti. There are two black alleles, so the color has to be black based (not blue, chocolate, or lilac). There are two full color alleles, so the rabbit is not chinchilla, shaded, pointed, or REW. There are two dense alleles, so the rabbit is full color and not dilute. And two full extension alleles, so the whole body is one color (no shading). This is the genetic make-up of a chestnut agouti.

I like to use a genotype cheat-sheet like this one to help me out with putting a name to each genetic sequence: <http://www.thenaturetrail.com/Rabbit-Coat-Color-Chart.htm>

But with your new knowledge, you will be better able to understand what those letters mean, and not only what the name of the color is. This way, you can better decide which rabbits to breed to get the results you want and determine what colors your rabbit may carry.

Here are some practice genotypes. Try them out (no cheat sheet) and see what you come up with! If you have any questions, please don't hesitate to e-mail me at oakridgerabbits@gmail.com for help or further explanation.

AaBBCcddEe	aabbCcDDEe	aaBbCCDdee
(at)aBbCcDdEe	A(at)bb(cchd)cDdEe	aaBbCcDdEe

aabbCCdee

(at)(at)BbccDdEE

aabbccdee