

It's easy as ...

ABC



About **B**unny **C**olors:

“Spelling out the essentials of coat color genetics”



A

**practical breeder's guide
to rabbit coat color.**



~Book Features~

Step-by-step explanations of how hereditary genetics work

85+ color photos

At-a-glance charts, tables, and illustrations

Interactive questions to help you check your knowledge

Extensive glossary

Tips on raising specific varieties

Integrated advice from leading breeders and judges

Color identification checklist

Descriptions and genotypes of 50 familiar varieties

Unique insight into the logical arrangement of color pigments

Insight on line breeding

And much more!

~Table of Contents~

Page 4... Introduction

Page 5... Chapter 1. "A practical understanding of the mechanics of genetics."

Page 6... What is a genotype?

Page 7... Breeding (Punnett) Squares

Page 10... The four basic colors

Page 14... Dominancy to the next level

Page 15... But what are my chances?

Pg17. Chapter 2. "Genotypes of familiar varieties."

Page 18... Spelling out the color gene sets

Page 19... B-series (black/brown)

D-series (dense/dilute)

A-series (pattern)

Page 22... C-series

Page 23... E-series (extension of dark pigment)

Page 24... Decoding a genotype

Page 25... How light and dark pigments are arranged

Page 27.... Coat color genotypes list

Page 29... Single-variety breed genotypes

Page 30-31.... Coat color photos

Page 32. Chapter 3. "When Cocoa and Sprinkles make a date" or "Practically applying genetic knowledge in your breeding."

Page 33... Rules for selecting breeding pairs

Page 34... Linebreeding

Page 37... When I breed Cocoa and Sprinkles, what color will the babies be?

Page 38... Genotyping rabbits

Page 39... Identifying the Junior Oddball

Page 45... Chapter 4. Your color breeding program Show groups vs. Genetic Groups

Page 46... Raising Agoutis

Page 47... Raising Chinchillas and Tri-colored.

Page 48... Raising Pointed Whites

Page 50... Raising Shaded

Page 51... Raising Tan Patterns. Raising Steels.

Page 52... Raising Silvers. Raising Wide Band colors.

Page 53... Chapter 5. Explaining the secondary color gene sets.

Page 53... The broken pattern gene (En)

Page 55... The Vienna (BEW) Gene (V)

Page 56... The Dutch gene (Du). The Silver Gene (Si)

Page 57... The wide band gene (W).

Page 58... Rabbit fur genes.

Page 61... Coat color glossary

Page 63... Appendix A: Descriptions and genotypes of familiar varieties

Page 65... Appendix B: Alternate names of varieties

Appendix C: Sources for obtaining more information

Page 67... Acknowledgements

A book

About Bunny Colors

“It’s as easy as ABC!”

A practical guide to understanding

RABBIT COAT COLOR GENETICS

And applying that knowledge in your breeding.

By Ellyn Eddy

A “Rabbit Smarties” Publication

© Copyright 2009, Ellyn Eddy.

All Rights Reserved.

Please visit our website:

www.RabbitSmarties.com

Contact the publisher through e-mail: Ellyn@RabbitSmarties.com

~Introduction~

When I was asked to write a coat color guide, I had to begin with the question, “Why would people want to read such a guide?” The answer I found was encouraging: because they want to learn.

And when an audience wants to learn something, it makes the author responsible to explain things in the most simple, straight-forward, and complete way possible. This I have tried to do in “A book About Bunny Colors”.

This book is meant to be a PRACTICAL guide to coat color genetics. Let me say as a disclaimer that I am not a geneticist, but a rabbit breeder with some experience and an interest in the subject. I cannot explain the mysteries of how the Creator caused hereditary genetics to work, but I can state the rules as we know them and guide you to a practical application in your breeding. The objectives of “A book About Bunny Colors” are as follows:

- I. Aid breeders in determining genotypes of their breeding stock**
- II. Enable breeders to determine the likely outcome of any given color cross.**
- III. Aid breeders in identifying coat colors in their litters.**
- IV. Enable breeders to use “A B C D E” terms with confidence and understanding.**
- V. Promote responsible use of the knowledge of coat color genetics among breeders.**

Like anything else, coat color genetics becomes actually easier to understand and much more interesting the more you learn about it. Maybe while reading this, you’ll be able to apply some of the things you learned about genetics in middle school science class. But if you’ve never had any experience with the subject, it will sound confusing until something “clicks”, and suddenly a whole field of discovery is within your reach.

Also, I would like to note that there is a lot of discrepancy as to coat color genotypes among breeders and authors. In writing this project I have studied as much as I could, and consulted many experienced breeders and judges, but in the end, there’s only one thing I know for absolute certain: that everyone will tell you something different! However, I have used my best judgment to present a book that is as accurate as I can make it. I encourage all my readers to keep an open mind and use logic and your own experience as guides. Also remember that scientists are still conducting research on rabbit genetics, and new discoveries could come to light at any moment.

If you have any comments or questions, feel free to contact me through the information on the title page.



Chapter 1



“What’s going on here?”

Or, “A practical understanding of the mechanics of genetics”

This book focuses heavily on the “what happens” with color genetics, not so much the “why” and the “how”. We’re trying to stay simple and practical. For this reason, I won’t discuss confusing realities like “a gene’s location on a chromosome” and DNA chemistry. If that’s your style, you can find enough of that information online to keep your head spinning. But if you just want to know what colors you’ll get when you breed your bunnies Cocoa and Sprinkles, read on.

Even if we don’t always understand **how** it happens in the physical body, we need to be familiar with **what** happens: how genes interact with each other to form coat patterns, and how the parents can give their traits to their offspring. That’s the purpose of this chapter.

We’ll start by discussing how genetics work. Then, once we’ve gained a basic understanding, we will be able to quickly plug in the rabbit color genes, and apply them to your own animals.

~Symbols~

What is this?

! # \$ % ^ & * + = ☺

Yeah it’s the alternate keys on the numeric row of my keyboard, but what else is it? **It’s a collection of symbols.** People use symbols to represent all sorts of things, like dollars, multiplication, happy faces, or genetics. Usually, people use letters (A, b, c^{chd}, for examples) to represent coat color genes. But if everyone agreed on it, we could use the symbol 🏆 just as well. In fact, for this chapter at least, we will.

~Dominancy~

Genetic characteristics often have two or more possibilities. For example, rabbits either have Rex fur, or not-Rex fur; good teeth, or malocclusion. One of the possibilities is usually stronger than the other. It is the one that will show if the genes for both types are present. This is called *dominant*. The dominant characteristic is given a large symbol (🏆). The weaker or *recessive* characteristic is given a smaller symbol (🏆). (The actual symbol is meaningless; I use trophies because our aim is to breed show-winning bunnies, right?)

~Carrying~

Breeders often use the term *carrying* as in “this buck carries bad teeth” or “this black doe carries chocolate.” By “carries” we mean, “this rabbit does not show XYZ characteristic, but does have the ability to pass it on to its offspring.”



Dominant: the gene that is shown in a genotype.

Recessive: the weaker form of a gene that only shows when a more dominant gene is not also present.

Carrying: term used to describe a trait that a rabbit does not show, but has the ability to pass onto its offspring.

Genotype: description in symbols of an animal’s genetic makeup.

“Carrying” is a real genetic term. The dominant gene is the one that shows, but a rabbit can “carry” a recessive gene. The big symbol  can “carry” the little one , right? Just like a big man can carry a small man—you may not see the little man hiding on his shoulders, but he’s there. In rabbit colors, black is dominant over chocolate. So, a black can carry chocolate. We write this as  .

However if we were to say that the chocolate “carries” black, this would be an incorrect use of the term because a recessive (little) gene cannot “carry” one more dominant than itself.

~Genotypes~

A *genotype* is a list of symbols noting the set of genes that an animal has. In other words, a genotype is a “gene code”, or a description of the rabbit’s genes written in symbols. Each rabbit gets a pair of variables that are represented by symbols. Here are some examples:

Genotypes:      

In simplistic terms, the first symbol in each pair is the actual color of the rabbit. The second symbol in each pair is the gene that it carries. Because the most dominant gene a rabbit possesses is the one that will show, the more dominant gene is always written first. Thus,   is not a correct genotype; it would properly be written  .

Let’s use the colors black and chocolate for examples. Black is dominant so we’ll say the big symbol means black. Chocolate is recessive; we’ll assign chocolate the small symbol. There are four possible genotypes:

  means a black that carries chocolate.

  means a black that does not carry chocolate.

  means chocolate. No black gene is present.



*In a correct genotype, the first symbol in each pair is the actual color of the rabbit. The second symbol in each pair is the gene that it carries. **The more dominant gene is always written first.***

🏆🏆 means black that carries chocolate--same as the first one, but for the sake of clarity we always write the dominant gene first, so this genotype is written incorrectly.

In the case that we don't know whether or not our black carries chocolate, we write a blank in the place of the second symbol, like this: 🏆 ____.

~Breeding Pairs~

Each rabbit, as we have said, has two variables in its genotype for each characteristic. **One of the variables comes from each parent:** that's how each rabbit has two. We are using forms of the trophy symbol to represent the black/chocolate characteristic. If a black rabbit had a chocolate *sire* (father) and a black *dam* (mother), it's genotype would be 🏆🏆, the black gene from the dam and the chocolate gene from the sire.

A rabbit may give to its offspring either one of its two variables. Every kit gets a chance at receiving either variable. So our 🏆🏆 rabbit may give either a black or a chocolate to each of its offspring. But if you have a black that does not carry chocolate, it will give a black gene to each of its offspring, because the chocolate gene isn't present. All chocolates will give the chocolate gene to every offspring, because if it had a black gene to give, it wouldn't appear chocolate itself.

🏆🏆 bred to 🏆🏆 = 🏆🏆 100%, because both parents can only throw the black gene.

🏆🏆 bred to 🏆🏆 = 🏆🏆 100%, because both parents can only throw the chocolate gene.

Breeding two recessive colors will never ever throw you a dominant one.

🏆🏆 bred to 🏆🏆 = 🏆🏆 100%, because one parent can only throw black and the other can only throw chocolate, so the kits get one of each. They appear black, but they can produce a chocolate. Make sense?

~Breeding Squares~

When we want to know what colors two rabbits can produce, we use a graph called a *Punnett Square*, or as we will call it, a *breeding square*, to find the answer.

X	Dam's gene 1	Dam's gene 2
Sire's gene 1		
Sire's gene 2		

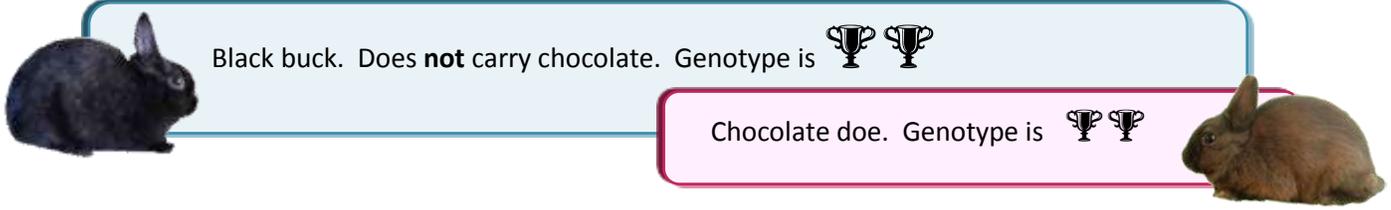
Table 1 is a Punnett Square frame that we need to fill in with our parent rabbits' information.

The blue squares are the sire's genes.

The pink squares are the dam's genes.

The purple squares are the offspring.

Let's hypothetically breed these rabbits:



Black buck. Does **not** carry chocolate. Genotype is 🏆🏆

Chocolate doe. Genotype is 🏆🏆

Filling in the square: Let's take the sire first. His genotype is 🏆🏆. Remember that he can give either of his two genes to his offspring, sometimes the first one in the pair, sometimes the second. Write the first possibility in his first square, and the second possibility in his second square. (Because both his genes are the same, both his squares read 🏆)

Do the same for the dam. She is 🏆🏆 and can only throw 🏆. Now we have *table 2*. Now solve.

Table 2.

X	Dam's gene 2 🏆	Dam's gene 2 🏆
Sire's gene 1 🏆		
Sire's gene 1 🏆		

Table 3.

X	Dam's gene 1 🏆
Sire's gene 1 🏆	🏆🏆

Table 4.

X	Dam's gene 1 🏆	Dam's gene 2 🏆
Sire's gene 1 🏆	🏆🏆	🏆🏆
Sire's gene 2 🏆	🏆🏆	🏆🏆

As we see in the completed square (*table 4*), all offspring are 🏆🏆: blacks that carry chocolate. Remember that the dominant symbol is always written first, no matter which parent it came from.

The square that we just did is more complicated than it had to be. Each blue or pink square represents a possible gene that the sire or dam can throw. When the parent has the same two symbols in a pair, it's redundant to write it twice. We could have left the whole thing at *table 3* and been just as correct.

When both symbols in a pair are the same, we call this *homozygous*. Homozygous animals are sometimes called "true breeding", because they will only throw the genes that they show in their coloration. They aren't hiding any recessive genes. When the two symbols are different, we call this *heterozygous*.

~Breeding Squares Practice~

The black to chocolate cross shown on the last page yielded no chocolate because the black didn't carry the chocolate gene. But if the black did, you could get both black and chocolate babies (see *table 5* below.)

As you will notice in *table 5*, the second column of purple squares is merely a repeat of the first one. This is because we wrote the chocolate dam two squares when really, she is homozygous for chocolate and can only throw one possible gene. Therefore you can cancel her second column. You can't cancel the buck's second row, though, because he can throw two different genes.

Example 2: Black-carrying-choc bred to chocolate. 🏆🏆 bred to 🏆🏆 (shown in *table 5*.)

Table 5.

	Dam's gene 1 🏆	Dam's gene 2 🏆	
X			
Sire's gene 1 🏆	🏆🏆 (Black—choc carrier)	🏆🏆 (Black—choc carrier)	 (second column can be canceled because both dam's genes are the same and the second column is a repeat of the first.)
Sire's gene 2 🏆	🏆🏆 (Chocolate)	🏆🏆 (Chocolate)	

Now try your hand at solving a breeding square! I'll do steps 1 and 2 for you. Here is your breeding pair:

Sire's genotype: 🏆🏆 Dam's genotype: also 🏆🏆 Both are blacks that carry chocolate.

Step 1. Find the genotypes of the parents.

Step 2. Draw the square.

Fill in the sire's and dam's genes.

Step 3. Now you solve *table 6*, at the right: In the purple "offspring squares", write the genotype on the first line and the color on the second, then check your answer in *table 7* on the next page.

Table 6.

	Dam's gene 1 🏆	Dam's gene 2 🏆	
X			
Sire's gene 1 🏆	_____	_____	
Sire's gene 2 🏆	_____	_____	

Now if we bred a chocolate to a chocolate there would be no need to make a

square. Both parents could only throw the chocolate gene, so all the offspring would be chocolate.

$$\text{🏆🏆} \times \text{🏆🏆} = 100\% \text{ 🏆🏆}$$

We see that **two recessive colors bred together can never throw a dominant one!**

How did you do?

Table 7. (Answers to table 6.)

X	Dam's gene 1 	Dam's gene 2 
Sire's gene 1 	 Black	 Black
Sire's gene 2 	 Black	 Chocolate



Homozygous: when both symbols in a pair are the same. This is also called "true-breeding" because the animal will not throw any genes it doesn't show.

Heterozygous: when the two symbols in a pair are different.

"Throw": verb used by breeders to mean "produce in offspring".

We have been talking about black and chocolate. By the dominant symbol  we have meant "black", and we have been calling the recessive symbol "chocolate". However, this is not the most accurate way to say it. Not only the varieties black and chocolate, but every known rabbit color is either black or chocolate based. It either has the dominant gene or the recessive one for the chocolate series. So instead of the word chocolate, it is better to use the term "brown". Examples of dominant gene (not-brown) colors are black, blue, chestnut, opal, Siamese sable, and smoke pearl. Examples of recessive (brown) gene colors are chocolate, lilac, chocolate otter, and lynx.

There is another gene set (gene series) which works in the same way as the brown series. This is the blue gene series, properly called "dilute". The dilute gene is the recessive gene. The dominant gene, like the dominant brown gene, has no effect on color.

Every color is either not-brown or brown, AND every color is either not-dilute or dilute. Thus we have four possibilities, and four basic rabbit colors...

~The Four Basic Colors~

Let's lay the genetics aside for a minute. Think about good old rabbit fur; think about our familiar recognized colors. Have you ever noticed that there are really only four basic rabbit colors? They are black, blue, chocolate, and lilac. **Every color on the planet has a black, chocolate, blue, or lilac basic color.** Every black based color has a corresponding chocolate, blue and lilac color. Here's a small sampling to show what I mean. For a longer list of colors broken into basic-color groups, see page 26.



Black Basic Color	Blue Based Counterpart	Chocolate Based Counterpart	Lilac Based Counterpart
Chestnut	Opal	Chocolate Agouti	Lynx
Tortoise	Blue Tortoise	Chocolate Tortoise	Lilac Tortoise
Chinchilla	Squirrel	Chocolate Chinchilla	Lilac Chinchilla

Every black color has a chocolate, blue, and lilac counterpart. But, not all of those counterparts are recognized. In fact—most of them aren't. This is especially true with chocolate and lilac based colors. As you see, most chocolate and lilac based colors do not have their own separate names because they are very similar to the black or blue based versions and would may not be accepted as a new variety. In the remainder of the chapter we will use the words "black, chocolate, blue, and lilac", but if we say "blue" for instance, we really mean any blue-based color. (As a side note, I prefer to use the terms black, blue, chocolate, or lilac "basic" or "based" color rather than "base color", because "base color" can refer to the undercolor of the coat, the shade next to the skin.



Recognized: (ARBA recognized).
 Breed or variety that the American Rabbit Breeders Association has approved to be shown at ARBA sanctioned shows, and has passed a written standard for it. Synonyms include "accepted" and "showable"
Variety: A show term meaning the standardized name that a color is shown as.

~ Back to the Genetics. No really, this is interesting! ~

Let's explain how the four basic colors happen genetically. We have been using the symbol  for the brown series. We will now add the "carrot" symbol  to mean the dilute series.

A big carrot  means the dominant "not-dilute" (also known as "dense") and the small carrot  means the recessive dilute. Remember that in terms of carrying and breeding, the dilute series functions in the same manner as the brown series we already explained. Here are our four possible gene combinations:



 ___  ___ not-brown and not-dilute (black).

  ___ brown and not-dilute (chocolate).

 ___  not-brown and dilute (blue).

  both brown and dilute (lilac).

The genetics for the four basic colors are easy to remember because it's also the way the varieties appear. A black has the dominant form of both genes. Blue looks like a diluted black. Chocolate looks brown. The variety lilac looks rather like you took blue and chocolate paint and mixed it up, doesn't it? Lilac is blue and chocolate combined, or in other words a diluted brown.

~ Interbreeding the Four Basic Colors ~

Before we start, let's do away with the funny symbols. I've been using the symbols  and  because I think that the normal alphabetical symbols only add to the confusion when trying to explain concepts like dominance or Punnett squares—up to a point. But if you understand that letters are just gene symbols, same as  can be, then there is no harm in using them. In fact, they are easier to recall than random pictures! So let's replace the picture symbols with letters of the alphabet.

Brown series: (formerly used ). For black we will use the capital B, and for brown, the lowercase b.

Dilute series: (formerly used ). For dense we will use the capital D, and for dilute, the lowercase d.

Okay, so now let's hypothetically breed some of the four basic colors together and see what happens.

Example A:

Step 1. Find the genotypes of the parents:

Blue buck. Does not carry brown. Genotype is BB dd

Black doe. Does carry brown. Does not carry dilute. Genotype is Bb DD.

Step 2. Find all the gene combinations that each rabbit can throw. Draw the square and fill in the sire's and dam's genes. Remember that each parent gives one symbol (gene) of each pair to every offspring. (That way, all the babies wind up with two.) **The sire and dam's squares are to represent all of the possible gene combinations that the respective parent could throw.** You can't draw the table until you come up with all their genetic combinations, because the number of squares you have to draw varies according to the rabbit's genotype.

Our dam's genotype is Bb DD. Take the genetic pairs one at a time. She will sometimes throw a **B**, so write that in the first square. She will sometimes throw a **b**, so write that in the second square. She is homozygous for **DD** and can only give **D** to her offspring, so write **D** beside the B-gene in each both squares. So the dam will give all of her kits either **B D** or **b D**. Now do the same with the sire. He is homozygous for both **BB** and **dd** so he has only one possibility. He will give a **B** and a **d** to every kit.

Step 3. Solve. We arrive at *table 8*. As you see, all offspring are black. However, all of the offspring inherited a dilute gene from the sire and they could throw a dilute color. Some of the offspring inherited the brown gene from the sire and could throw a brown (chocolate or lilac-based) color. Even though all the babies appear the same, it is important to remember those hidden genes for future breeding.

Table 8.

X	B D	b D
B d	BB Dd (Black)	Bb Dd (Black)

Let's try another example. Example B: **Step 1. Find the genotypes of the parents:**



Chocolate buck. He does not carry dilute. Genotype is bb DD.

Dam is a Lilac doe. Genotype is bb dd.



Step 2. Simplify by cancelling all like homogenous pairs. As you see, both parents are brown-based colors, and therefore “true-breeding” for the recessive brown gene (**b**). We know that both parents only have one variable to give and that it is the same variable. So all offspring will also be homozygous for that variable. Therefore we can leave the brown series out of the equation entirely, remembering that all kits are **bb**. Now, both parents are also “true-breeding” for their respective D-series gene. But, it’s not the same D-series gene with both parents. So no cancelling can be done there.

Sire:	bb	DD
Dam:	bb	dd

Table 9.

X	d
D	Dd (Chocolate)

Step 3. Find all the gene combinations that each rabbit can throw. Draw the square and fill in the sire’s and dam’s genes.

Step 4. Solve. (table 9). There is only one possible outcome. We see that all kits are **bb Dd**: chocolate carrying dilute.

Can you take one more? Let’s “breed” a pair of blacks. This time both parents carry brown and dilute.



Step 1. Find the genotypes of the parents. Sire: Bb Dd. Dam: Bb Dd.

Step 2. Simplify by cancelling all like homozygous pairs. With this mating, no simplification can be done. Though both parents have the exact same genotype, the gene pairs are not homozygous. If we did any cancelling, we would rule out the hidden recessive genes. Only when parents are “true-breeding” for the same gene can cancelling be done.

Step 3. Find all the gene combinations that each rabbit can throw. Draw the square and fill in the sire’s and dam’s genes. Remember we are trying to discover every gene combination that the sire or dam could give to their offspring. The sire might give a **B**, and he might give a **b**. He might give a **D**, and he might give a **d**. He has four possible combinations to give his offspring, as shown in table 10 below. Because the dam has the same genotype, her side will be same as the sire’s.

Table 10.

X	B D	b D	B d	b d
B D	BB DD (Black)	Bb DD (Black)	BB Dd (Black)	Bb Dd (Black)
b D	Bb DD (Black)	bb DD (Chocolate)	Bb Dd (Black)	bb Dd (Chocolate)
B d	BB Dd (Black)	Bb Dd (Black)	BB dd (Blue)	Bb dd (Blue)
b d	Bb Dd (Black)	bb Dd (Chocolate)	Bb dd (Blue)	bb dd (Lilac)

Step 4. Solve. As you see, all kits will have one of sixteen possible gene combinations. Most of the gene combinations (genotypes) result in the color black, but because the black parents hide recessive genes, mating them together may also produce blue, chocolate, or lilac. Even most of the black babies will carry brown and/or dilute. We cannot forget those hidden recessive genes! They can be passed down for generations and then appear seemingly at random.

~Dominancy to the next level~

Each set of symbols ( ,  , B, D, --for examples) is called a gene series. The brown and the dilute series are the most simple ones. They have only two members: a dominant gene and a recessive one, a “big” and a “little”. The “big” is completely dominant over the “little”.

But supposing there was a third possible gene: a “big”, a “little”, and one in between. We will use the symbol  to illustrate.

 is dominant over  which is dominant over 

Let’s assign these genes real rabbit colors.  = Chestnut,  = Black Otter,  = black. See the photos on pages 29-30 for examples of these colors.



Castor Rex

Notice that these are all black-based colors. The only genetic difference between them is that one is agouti pattern, one is tan pattern, and one is self pattern. If we were to illustrate with blue-based colors, we could use opal, blue otter, and blue.

Now, even though there are three genes in this series, each rabbit can only possess one or two. All rabbits have a two-symbol genotype for every series. Let’s take a look at some genotypes. The most dominant gene in a rabbits’ genotype is the color that shows.

 ___ is chestnut, or agouti. It could be  ,  , or  . These all appear chestnut.

 ___ is otter, or in other words, tan pattern. It could be homozygous  , or it could be carry self and be  . But it would never be  , because otter is less dominant than chestnut and a lesser gene can never hide one higher on the hierarchy.

  is black, or in other words, self pattern. It will always be homozygous because self pattern is the most recessive gene and cannot hide any of the others. If it shows, it’s double self.

~Taking a look at some crosses~

But instead of using the symbol , we’re going to use forms of the letter “A”. Remember these are just symbols used for genes.

- A** = Agouti Pattern (chestnut).
- a^t** = tan pattern (otter).
- a** = self pattern (black).



Even in gene series with more than two possible genes, each rabbit can only possess one or two. Genes come in pairs.

Anytime the agouti (chestnut) gene is present, it will show, because it is the most dominant.

A rabbit with the genotype **AA** bred to anything will produce 100% agoutis, because the **AA** parent will always contribute the dominant agouti gene. No matter if the offspring are **AA**, **Aa^t**, or **Aa**—they will appear chestnut.

Both parents have to possess (carry or express) a recessive gene for it to appear in the offspring.

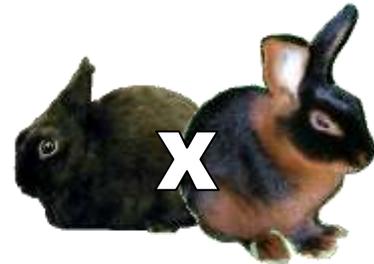
Example #1: **A a^t** x **a^t a^t**. Sire is a chestnut who carries otter. He is bred to a homozygous otter doe. Our two possible outcomes are **Aa^t** and **a^t a^t**: chestnut and otter. Notice that all kits will carry otter because doe is homozygous for otter. This cross will never produce a black, because the black gene simply isn't present.

Example #2: **A a** x **a a**. Sire is chestnut-carrying-black and dam is black. This cross will result in chestnut and black, and all the chestnuts will carry black. No otters will occur because the otter gene is not present.

You determine example #3: **a^t a** x **a a**. Could this cross produce blacks? Otters? Chestnuts?

Your answer _____.

Correct answer to #3: This cross would yield otters and blacks, but never a chestnut because the chestnut gene just isn't there. Two recessive colors can never throw one that is more dominant.



Example #4: **A a** x **a^t a** Sire is a chestnut and dam is an otter. Both carry black. Let's take this one to a breeding square (*table 11*).

~But what are my chances? ~

Table 11.

X	a^t	a
A	A a^t (chestnut)	A a (chestnut)
a	a^t a (otter)	a a (black)

What percentage of the offspring will be each of the possible colors? Well, look at your Punnett square. If there is only one offspring space, like in *table 9* on page 11, your chances for that color are 100%. It's the only one you can produce. If you have two offspring spaces, like in a **Bb x bb** cross, then each kit has a 50% chance of being either genotype. But if you have four offspring spaces, like in *table 11* at the left, each kit has a 25% chance of being each of those spaces. And so on, and

so forth. Realize that this means each kit has an "xyz" percent chance of being each possible *genotype*, not necessarily each possible color. Like in *table 11*, there are four possible genotypes, but only three possible colors. Each kit has a 25% chance of being each genotype, but because half of the genotypes result in chestnut, each kit has a 50% chance of being chestnut.

Notice that I keep saying “**each kit** has such-and such a chance”. If I said that “in a litter of four, exactly half will be chestnut, one will be a otter, and one will be a black”, I would likely be incorrect. We can’t predict the exact outcome: they could all be chestnuts! But the potential is there for producing all three colors, and each kit has a 25% chance of being each genotype. Here’s why we phrase it that way:

Producing a baby rabbit is like drawing a marble out of a jar—and putting it back again before drawing another one out. If there are four marbles in the jar, the law of probability says that we have a 25% chance of selecting each one. But every kit gets to start fresh...they *could* draw out the very same “marble” as all their siblings before them. But this is being theoretical. Practically speaking, **the over-time result is basically that 25% of your kits will be each genotype, supposing there are four genotypes possible.**



~Breeding Squares Practice~

Being able to create and solve a breeding square for your cross is an important skill in understanding color genetics. They can be a little tricky to figure out, however, so this page is included as a practice. Three hypothetical crosses are given. We give the parents’ genotypes and the Punnett square, and you fill it in and solve. Answers are provided at the bottom. Don’t be concerned about the actual colors that the genotypes mean—the aim is to get the genotype right. Chapter 2 is all about decoding a genotype.

Helpful Tips: Notice that the sire’s and dam’s boxes contain only one symbol per series. The offspring’s boxes each have two symbols per series. The sire’s and dam’s symbols come together to create the offspring’s genotype. When filling in the sire’s and dam’s squares, start with the most dominant genes and work your way down. When written correctly, the most dominant color will be in the upper left offspring square, and the most recessive color will be in the bottom right.

Practice Cross #1: (Table 12). Sire’s genotype: $a^t a$ Bb dd. Dam’s genotype: $a^t a^t$ BB Dd.

Practice Cross #2: (Table 13). Sire’s genotype: Aa Bb dd. Dam’s genotype: $a^t a$ Bb dd.

Table 12. Practice 1.

X		

Table 13. Practice 2.

X				

Answers on page 58 in the back.

Chapter 2



“Like multicolored Christmas lights, let's plug the colors in.”

Or, “Genotypes of familiar varieties.”

In the last section we talked about how hereditary genetics work. In this section we will give you the rabbit color genes to plug into the framework outlined in Chapter 1, and you will learn the genetics of every recognized color. This chapter will probably be the most confusing one, but don't get discouraged because in Chapters 3 and 4 coming up, we will expand on how to apply this knowledge profitably in your breeding.

~As easy as ABC~

Remember that a set of genes or gene symbols is called a series. Each set controls a certain characteristic and the different gene sets work together to form all the known rabbit colors. **There are five major sets that determine coat color in rabbits.** They are symbolized by the first five letters of the alphabet:

A B C D E

We have already discussed three of these series under the guise of symbols:   .

~It's those genotypes again~

This is a genotype: Aa Bb Cc Dd Ee

A genotype is a bunch of symbols that represent the genetic code of an individual rabbit (or person, or dwarf hamster, or whatever you will.) This is another genotype: AA BB CC DD Ee

Both of those two genotypes represent the same rabbit color, because the dominant (first) symbol in every pair is the same. You look at the first letter in every pair to determine the color. Thus the genotype:

a'a BB c^{chd}c^{chl} dd Ee

results in a different color than the other two, because some of the first symbols in a pair are different. (The first and second genotypes mean chestnut, the third means blue silver marten.) Remember: symbols in a genotype always come in pairs. We look at the first symbol in each pair to determine the color. We look at the second symbol in each pair to tell what recessive gene the rabbit carries and may give to each offspring. Each rabbit can only hide one recessive gene! In the case that we don't know what recessive gene a rabbit carries, we write a blank in the place of the second symbol, like this: A__ B__ c^{chd}__ D__ E__



REVIEW: Remember that a parent gives one of its two "symbols" in each gene pair to its offspring. (Random chance with each kit as to which of the genes the parent will throw.) Thus, in a genotype, we know that one of the symbols in each pair was contributed by either parent. The dominant symbol in each pair is always written first, no matter whether it came from the sire or the dam.

~The Wild Type~

We explained in the last chapter that every gene has a dominant form, noted with a large symbol or uppercase letter. Any recessive genes are written with a small symbol or lowercase letter. So a rabbit with the genotype A __ B __ C __ D __ E __ would have every gene in its dominant form.

Now here's the interesting thing: the genotype A __ B __ C __ D __ E __ results in the wild rabbit color, that which we call chestnut agouti. Chestnut is the "original" or "default" rabbit color, and all other color genes are mutations or variations from the original. In this chapter we will discuss these mutations that give us all our known colors of today. Remember that the same genetic color may have different names in different breeds. Chestnut, for an example, was originally called "gray" and still is in the Dutch breed. It's called "copper" in Satin breeds, "castor" in Rex breeds, and "brown" in the Silver. For a chart of how color names vary from breed to breed, refer to page 63. Also, colors may appear differently from breed to breed based on the fur type.

Interested in reading the rest of the book?

Grab it at this link: RabbitSmarties.com

Please tell your friends to find us online at RabbitSmarties.com, and on Facebook, Twitter, and Pinterest!



Hey Check this out!

TheNatureTrail.com - A Virtual Treasure Chest of Rabbit Information



The Nature Trail has been a beloved source of rabbit information since 2004, offering great numbers of photos and over 500 articles on rabbit judging, care, health, and husbandry, and hosting hundreds of thousands of visitors. Features hundreds of cute and funny bunny photos.

RabbitSmarties.com - Creative Resources for Rabbit Breeders and 4-H Members & Leaders

From a detailed coat color genetics guide to design services that can help you better market your rabbit business, to insider tips for ARBA royalty and 4-H showmanship participants, www.RabbitSmarties.com offers helpful resources for rabbit lovers of all kinds.



If you enjoy our websites, please share them on Facebook, Pinterest, or your own website! Thanks!

Need Rabbit Supplies?

Check out PremiumRabbits.com

“Equipping you for success!”



- Cages
- Carriers
- Feed & Water equipment
- Books & DVDs
- Cage building supplies
- Tattoo equipment
- Toys & Accessories
- And lots more!

Hurry over to PremiumRabbits.com to see the deals on rabbit equipment!

We also offer custom rabbitry logos and pedigrees at
TheNatureTrail.com

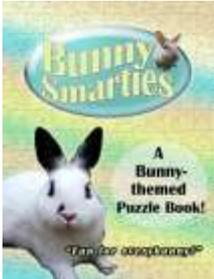
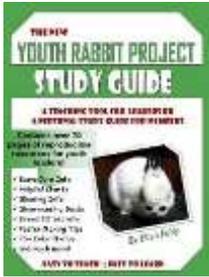
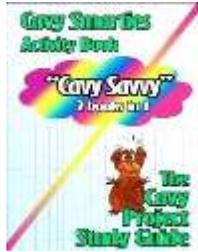
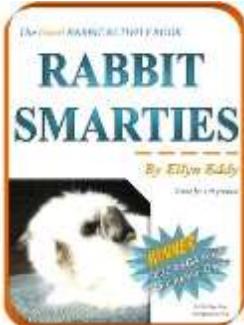
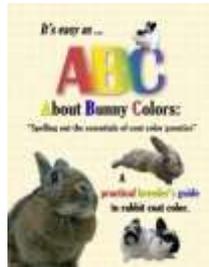
Babydoll Bunnies



*Skittles'
Hutch
Bunnies*



Logo by
TheNatureTrail.com

<p>"Bunny Smarties" Featuring over 70 puzzles, games, and activities with a rabbit theme. Includes crosswords, word scrambles, coloring, picture games and much more. Adorable color photos and informational paragraphs throughout. It doesn't matter whether you have never owned a rabbit, or enjoy keeping one as a pet, or are an experienced rabbit breeder; if you like puzzles, Bunny Smarties is for you! 48 pages. Comb bound. Printed in full color. \$12.00 + S/H</p>	
<p>"The Youth Rabbit Project Study Guide" Written for the youth 4-H or ARBA rabbit project member, the "Youth Rabbit Project Study Guide" provides everything you need to know to succeed with your rabbit project. Includes complete coverage of selection, breeding, showing, care, and health. Detailed guide to contests such as showmanship, breed ID, and meat pens. Information is presented in unique, easy-to-learn charts, tables, and colorful graphics. The Study Guide has received widespread acclaim from 4-H leaders in the past year. \$20.00</p>	
<p>"2-in-1: Cavy Smarties and Cavy Study Guide" Get the best of both worlds in this combination study guide and activity book about guinea pigs! Great for a 4-H cavy project or for rabbit royalty contestants that need to study cavies for the competition. Printed in full color. AVAILABLE NOW! \$20.00</p>	
<p>"Rabbit Smarties" Featuring over 115 puzzles, games, and activities with a rabbit theme. Includes crosswords, word scrambles, coloring, picture games and much more. Adorable color photos and informational paragraphs throughout. Rabbit Smarties is geared toward 4-H'ers and the ARBA show circuit aspects rabbit raising, breeding, and showing. (Whereas Bunny Smarties is geared toward the novice pet rabbit owner, or the general public.) Rabbit Smarties is popular nation-wide as a teaching aid for 4-H youth clubs. A previous knowledge of rabbits is helpful to complete this book. 68 pages. Comb bound. Printed in full color. \$15.00 + S/H</p>	
<p>"A book About Bunny Colors" presents simplistic, breeder-oriented explanations of the rules of rabbit coat color genetics. Focus is on the "what happens" with coat color genetics, so that you can accurately use the information without having to grasp all the "why's" and "how's". Information is presented in a reader-friendly format with simple language, visual aids, and of course lots of full-color pictures. This book includes tips from several leading breeders and insight into the place of coat color in the rabbit world today. Get ready for discoveries with "About Bunny Colors"--a book for breeders! \$20.00</p>	

Please visit www.RabbitSmarties.com for free resources!