Satin and Mini Satin Genetics Made Easy, by Dan Erz 5/12/2011

It is important when discussing colors with Rabbit Breeders to separate **Phenotype** (Description of a Rabbits Appearance) and **Genotype** (The Genetic Code Structure of the Animals Genes based on its DNA).

Inside most cells in every animal is DNA - the blueprint that dictates how the animal looks and behaves.

Genes always contain two copies for everything including fur color. The two copies might be identical coding for the same color or they might not be identical. They might each code for a different color or characteristic. If so, one characteristic will be dominant, and the other is simply a duplicate, or recessive.

One of these genes comes from the Sire and one from the Dam. They combine in the offspring, bringing the total gene count back up to two each.

Some genes are dominant, and some are recessive. The dominant gene is visible and the recessive gene is hidden unless it is paired with another recessive match. In fact, you might never know a recessive gene is there, unless it gets passed down to an offspring and paired with a matching recessive gene. Two matching recessive genes together in a pair are visible as is one dominant gene by itself. Some recessive genes however, do effect (alter) the expression of the paired dominant gene, making it appear darker or lighter for example.

There are three main genetic traits Mini Satin breeders are concerned with, color, fur, and dwarfism.

Standard Satin breeders are concerned with color and fur genetics but not dwarfism.

Genetically there are (3) Color Pattern Types: Agouti, Tan and Self: The most dominant one is the Agouti Pattern. Next is the Tan Pattern which is slightly less dominant and then Self is the least dominant. An agouti can carry a duplicate gene for Agouti, or carry a recessive gene for either Tan or Self. A Tan can carry only Tan and Self. A Self can carry only Self. Examples of an Agouti are Copper and Chinchilla. Examples of a Tan are Otter and Marten. Examples of a Self are solid colors, solid Black or Chocolate or Blue or Lilac.

Genetically, all colors start from Black or Brown (Chocolate): Black is dominant, brown is recessive. With the dilute gene, however, Black can be modified into Blue and Brown (Chocolate) can be modified into Lilac. Therefore, all colors are a variation of those four, Black, Blue, Chocolate

and Lilac. Black and Brown rabbits normally have Brown eyes and the dilutes, Blue and Lilac normally have Blue-Gray Eyes.

Dominant genes are always written in upper case, whereas recessive genes are always written in lower case. Dominant genes cover up the expression of recessive genes, so it makes sense to put them in bigger, bolder letters. Since the dominant genes mask the little recessive genes, you can get colors in litters other than what the parents are, because they might both be hiding those little recessives.

When writing genotypes for rabbits, we always go in alphabetical order. There are five groups of genes commonly used in rabbit Genotypes, called loci, and they are as follows in order of most dominant to least dominant (recessive), with some common examples of colors displaying after the hyphens:

A – Agouti locus – "A" (Agouti) or "a^{t}" (Tan Pattern, such as Otters) or "a" (Self – solid colors).
B - Brown locus – "B" (Black) or "b" (Brown also know as Chocolate).
C - Color locus - "C" (Full Color) or "c^{chd}" (Chinchilla Dark - Chinchillas) or c^{chm} (Chinchilla Medium, a lighter version of the Chinchilla Dark) "c^{chl}" (Chinchilla Light – Sable Point, Smoke Pearl) or "c^{h}" (Pointed White - Himalayan, Californian, Pointed White) or "c" (REW – Ruby Eyed White – Albino). NOTE: $c^{ch1,}$ c^{ch2} and c^{ch3} are the technically correct ways of describing these genes according to the Genetics Society of America. However, in rabbit breeder circles and in rabbit genetics books, c^{chl}, c^{chm} and c^{chd} are used to simplify remembering each.
D- Dilute locus – "D" (Dense – will have brown eyes, colors such as Black and Chocolate) or "d" (Dilute – will have blue-gray eyes, colors such as Blue and Lilac)
E- Extension locus - "E^{d}" (Dominant Black) or "E^{s}" (Steel) or "E" (Normal Extension - Black) or "e^{j}" (Japanese Brindle – Harlequin, Tricolor) or "e" (Non-Extension - Torts, Orange).

Remember, every mammal has a pair of two genes. Every mammal inherits one gene from each "set" from the mother (DAM) and one from the father (SIRE) to make a complete paired set. Normally, never do the offspring get both genes from only one parent.

Agouti Patterns: "A" – Most Dominant Pattern		
Color	**Genetic Code**	**Modifier Description**
Copper	**A_ B_ C_ D_ E_**	**(A_) makes Agouti Pattern**
Chinchilla (Black)	**A_ B_ c^{ch3}_ D_ E_**	**(c ^{ch3}) is chinchilla dark modifier**
Squirrel (Blue Chinchilla)	**A_ B_ c^{ch3}_ dd E_**	**(dd) is Dilute modifier – Blue from Black**
Red	**A_ B_ C_ D_ ee ww**	**(ww) is wide band modifier and ee is lower extension which together make Red from Copper**
Opal	**A_ B_ C_ dd E_**	**(dd) is Dilute modifier – Blue from Black, so a Copper to Opal**
Chocolate Agouti	**A_ bb C_ D_ E_**	**(bb) turns the Copper into a Chocolate Agouti**

Tan Patterns: "a^t"		
Color	**Genetic Code**	**Description**
Black Otter	**a^t _ B_ C_ D_ E_**	**(a^t _) makes Tan Pattern**
Blue Otter	**a^t _ B_ C_ dd E_**	**-**
Chocolate Otter	**a^t _ bb C_ D_ E_**	**-**
Lilac Otter	**a^t _ bb C_ dd E_**	**-**
Black Silver Marten	**a^t _ B_ c ^{chd}_ D_ E_**	**(c ^{chd}) turns an Otter into a Silver Marten**
Blue Silver Marten	**a^t _ B_ c ^{chd}_ dd E_**	**-**
Chocolate Silver Marten	**a^t _ bb c ^{chd}_ D_ E_**	**-**
Lilac Silver Marten	**a^t _ bb c ^{chd}_ dd E_**	**-**
Smoke Pearl Marten	**a^t a B_ c ^{chl}_ dd E_**	**(c ^{chl}_ dd) turns a Black Otter into a Smoke Pearl Marten**

Self (Solid) Patterns: "a"		
Color	**Genetic Code**	**Description**
Black	**aa B_ C_ D_ E_**	**(aa) makes Self Pattern**
Blue	**aa B_ C_ dd E_**	**(dd) is Dilute – Blue from Black**
Chocolate	**aa bb C_ D_ E_**	**(bb) is Brown – Chocolate from Black**
Lilac	**aa bb C_ dd E_**	**(dd) is Dilute – Lilac from Chocolate**
Tort	**aa B_ C_ D_ ee**	**(ee) is Non-Extension that makes a Tort from a Black**
Californian	**aa B_ c^h_ D_ E_**	**(c^h) is pointed white modifier**
Satin Siamese - Black	**aa B_ c^{chm} _ D_ ee**	**(c^{chm}) is Chin Medium gene**
Satin Siamese - Blue	**aa B_ c^{chm} _ dd ee**	**(c^{chm}) is Chin Medium gene**
Satin Siamese (Darker) - Black	**aa B_ c^{chd} _ D_ ee**	**(c^{chd}) is Chin Dark gene**
Satin Siamese (Darker) - Blue	**aa B_ c^{chd} _ dd ee**	**(c^{chd}) is Chin Dark gene**

- **White** - __ __ cc __ __ - REW (Ruby Eyed White - Albino) (Recessive) can be any of the above including broken. The (cc) makes it an albino which over-rides all other pattern and color genetics every time.

- The **most common** Genotype for Siamese in the Satin and Mini Satin Breeds is aa B_ c^{chm} _ D_ee. It is important to note that Siamese Sable, as other breeds label Siamese carries the Genotype of aa B_ c^{chl} _ D_ E_. This is important to know when discussing Siamese genetics with breeders of Siamese Sable in other breeds. The primary difference is that a Siamese Sable Phenotype in other breeds calls for an undercolor slightly lighter then the surface color where as the Satin and Mini Satin Siamese Phenotype according to the SOP (Standard of Perfection) calls for an off white or cream undercolor. Another acceptable Genotype that fits the Satin or Mini Satin Siamese SOP description is aa B_ c^{chd} _ D_ee.

- aa B_ c^{chl}_ D_ee would create a very light surface color and is called Sable Point.

- Broken Gene (Dominant) – En en – Like dwarfism, broken is a dominant trait. Only one parent needs to be a Broken to make a broken. Two solids can not make a broken since it is not recessive. A Broken = En en, A Solid = en en, A Charlie (Overly Broken Broken) = En En – This is a broken with very little color, normally missing eyes rings and or nose markings and is called a Charlie since they resemble Charlie Chaplin.

Punnett Squares are used from this point forward to show gene pairings.

Sample Color Pairing: Chocolate DAM with a Black SIRE that carries Chocolate.

	Chocolate DAM GENE 1 (b)	**Chocolate DAM GENE 2 (b)**
Black SIRE GENE 1 (B)	**Black offspring** **B b**	**Black offspring** **B b**
Black SIRE GENE 2 (b)	**Chocolate offspring** **b b**	**Chocolate offspring** **b b**

Multiple Sample Color Pairings: With Modifiers (Dilute Used for this Example):

	Black DAM (BD)	**Chocolate DAM (bD)**	**Black DAM that carries dilute (Bd)**	**Chocolate DAM that carries dilute (bd)**
Black SIRE (BD)	**BB DD Black offspring**	**Bb DD Black offspring**	**BB Dd Black offspring**	**Bb Dd Black offspring**
Chocolate SIRE (bD)	**Bb DD Black offspring**	**bb DD Chocolate offspring**	**Bb Dd Black offspring**	**bb Dd Chocolate offspring**
Black SIRE that carries dilute (Bd)	**BB Dd Black offspring**	**Bb Dd Black offspring**	**BB dd Blue offspring**	**Bb dd Blue offspring**
Chocolate SIRE that carries dilute (bd)	**Bb Dd Black offspring**	**bb Dd Chocolate offspring**	**Bb dd Blue offspring**	**bb dd Lilac offspring**

Sample Pattern Pairings: Tan DAM that carries Self and an Agouti SIRE that carries Self.

Remember that Agouti is most dominant of the 3 patterns, then Tan and then the least dominant is Self (Solid).

	Tan Pattern (e.g. Otter) DAM GENE 1 (a^t)	**Self Pattern (Solid) DAM GENE 2 (a)**
Agouti Pattern SIRE GENE 1 (A)	**A a^t** **(Agouti)**	**A a** **(Agouti)**
Self Pattern SIRE GENE 2 (a)	**a a^t** **(Tan – Otter)**	**a a** **(Self – Solid)**

Is it a Lynx or is it not, that is the question? A Lynx is a Lilac Agouti. Therefore, a Lynx will have Agouti rings with Dove Gray or off White undercolor, Fawn intermediate color and Lilac (grayish) tipping and a belly undercolor that is Lilac. Many other colors are mistaken and even miss-registered as Lynx, especially Brokens. The Genotype for a Lynx is A_ bb C_ dd E_. There are "look-alikes", if you are not paying close attention or if there are smut issues. They are Cream A_ B_ C_ dd ee and Lilac Cream A_ bb C_ dd ee and Blue Fox at_ B_ C_ dd ee and Lilac Fox at_ bb C_ dd ee and Blue Tort aa B_ C_ dd ee and Lilac Tort aa bb C_ dd ee. Furthermore, to be an Agouti one of the parents must be an Agouti since Agouti is dominant. Any Lynx that has Tan pattern and or Self pattern parents is not an Agouti and is therefore not a Lynx, PERIOD. The easiest way to check for this, is that an Agouti animal with Full Extension (A_E_) will have agouti rings, of which none of the "look-alikes" will have. Also, in the case of Lynx, a Lilac belly undercolor will not be found on any of the "look-alikes", so a quick blow on the belly will tell the truth every time.

Satin Gene (Recessive) – "sa" satin fur, "Sa" is normal. The Satin gene was a major mutation that occurred in the United States in the rabbitry of Walter Huey of Pendleton, Indiana. Huey, was a dedicated breeder of Havanas, and in trying to improve their brown color and fur qualities, he began to inbred his stock. During this process, the first Satin mutation occurred in 1934. Walter Huey, sent animals to Harvard University, where geneticists determined that this new mutation was a simple recessive gene. There are two basic differences in Satin Fur: (1) a finer diameter hair shaft then other fur types and (2) a

transparent hair shell (cuticle). Satins appear more brilliant in color compared to normal fur breeds. The sheen is due to the clarity of the glass like hair shell and its ability to reflect light. The coat should be well balanced, with uniform length.

Dwarf Gene (Dominant) – “Dw dw” is a True dwarf, “dw dw” is a False dwarf (normal) and “Dw Dw” or a Double dwarf is a Peanut. Mini Satins are a dwarf breed, like Holland Lops, Mini Rex, Netherland Dwarfs and Dwarf Hotots for example. With regard to the dwarf gene, there are True dwarfs, False dwarfs, and Peanuts. Peanuts do not grow and always die, usually within a few days, but occasionally last a week or two. False dwarfs are also called "normals" and can make good brood animals. Show rabbits are typically True dwarfs. False dwarfs are more likely to be long, have longer ears and back feet, and often exceed maximum adult weight according to the SOP. These are tendencies and not absolute proof of being a False dwarf. The rabbits that most often do well on the show table are True dwarfs. They tend to be truer to type--shorter, with shorter ears and back feet, more balanced, and more likely to fall within the allowable show weight range. You will recognize peanuts in your litter by several characteristics. First, at birth Peanuts weigh about 3/4 of an ounce, whereas other kits weigh about 1 1/2 ounces or more. Peanuts may have bulging skulls and eyes with ears that are set further back. Also their hips are often underdeveloped and their back legs may cross. So how do you breed for true dwarfs? You might be tempted to think that breeding a true dwarf to a True dwarf would yield a litter of True dwarfs. But that's not how it works. First, we need to know that a True dwarf has one "dwarf gene" and one "normal gene". A False dwarf has two normal genes and a Peanut has two dwarf genes. If you breed two True dwarfs together, on average one of four would be Peanuts, two of four (or 1/2) would be True dwarfs, and one of four would be a False dwarf. Since the Peanuts will certainly die, two out of three of the surviving kits would be True dwarfs and one out of three would be a False dwarf. Remember, these numbers are averages, so your actual results may vary. What does this all mean for your breeding program? If you are breeding toward the standard and wish to successfully show your rabbits, at least one parent should be a True dwarf. But it is clearly obvious that you do not need to have both parents to be True dwarfs to produce a True dwarf. Sometimes breed True dwarfs together, even though 1/4 of the litter, on the average, will die. If the two rabbits complement each other and it is a good pairing, breed true dwarf to true dwarf. The balancing of strengths and weaknesses is the most important factor. Producing or not producing Peanuts is secondary. Most often though, breed a True dwarf buck to a False dwarf doe. A False dwarf doe has an easier time kindling and caring for her young, especially if the kits are larger or there are many of them. False dwarfs seem to maintain their weight better

and are prepared to kindle again sooner. Remember, even if you breed two true dwarfs together, you will have some False dwarf kits. If you wonder whether your rabbit is a true or false dwarf, breed it to a known True dwarf. If there are peanuts in the resulting litter, your rabbit is definitely a True dwarf. If not, it is probably a False dwarf, though with a small number of offspring, this conclusion is not totally reliable. With repeated breeding between True dwarfs that do not produce peanuts, you can safely conclude that at least one parent is a False dwarf.

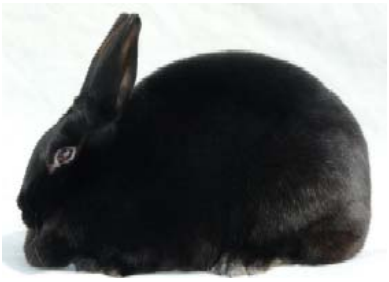
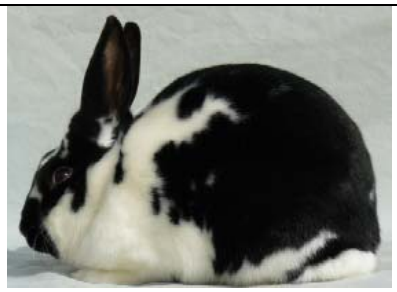
Breeding of 2 True Dwarfs	True Dwarf DAM GENE 1 (Dw)	True Dwarf DAM GENE 2 (dw)
True Dwarf SIRE GENE 1 (Dw)	Offspring = Peanut (Dies) Dw Dw	Offspring = True Dwarf Dw dw
True Dwarf SIRE GENE 2 (dw)	Offspring = True Dwarf Dw dw	Offspring = False Dwarf dw dw

Breeding of 1 True Dwarf and 1 False Dwarf	False Dwarf DAM GENE 1 (dw)	False Dwarf DAM GENE 2 (dw)
True Dwarf SIRE GENE 1 (Dw)	Offspring = True Dwarf Dw dw	Offspring = True Dwarf Dw dw
True Dwarf SIRE GENE 2 (dw)	Offspring = False Dwarf dw dw	Offspring = False Dwarf dw dw

On average, both of these examples will produce 2 True dwarfs out of 4. The top example produces 1 Peanut that dies and 1 False dwarf that makes a good brood if it is a doe. The bottom example produces 2 False dwarfs that make good broods if both are does.

The next 3 pages demonstrate why color rabbit breeders that venture into shaded colors need a strong heart and need to know what they are doing to avoid creating DQ colors that look one way but are really genetically different, or get used to culling out large percentages of each litter.

Picture Page

 Black	 Blue	 Broken
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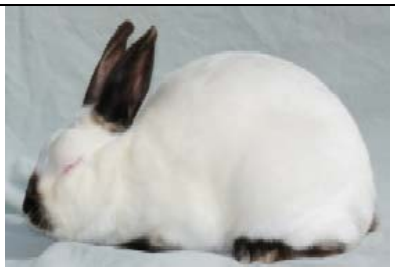
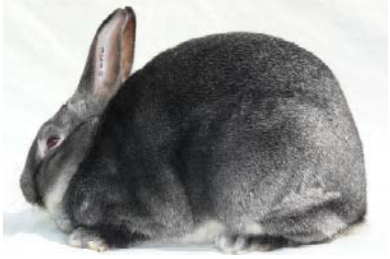
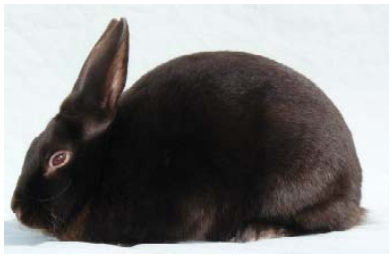
 Californian	 Chinchilla	 Chocolate
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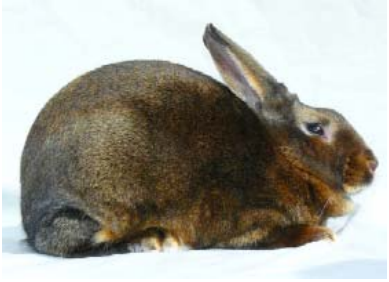
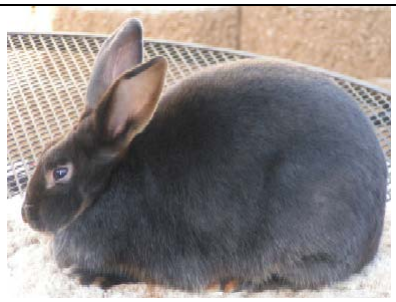
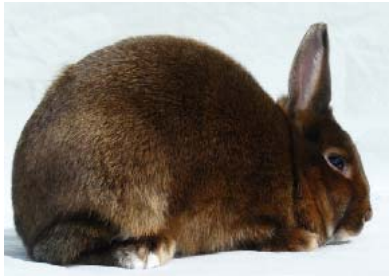
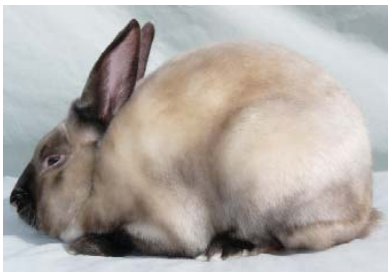
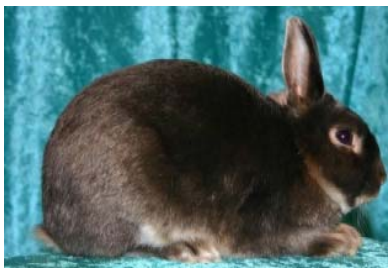
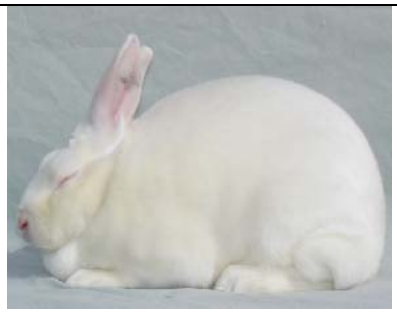
 Copper	 Black Otter	 Red
A_ B_ C_ D_ E_	a^{t} _ B_ C_ D_ E_	A_ B_ C_ D_ ee ww
 Siamese	 Opal	 White (REW - Albino)
aa B_ c^{chm} _ D_ee (Satins and Mini Satins only)	A_ B_ C_ dd E_	__ __ cc __ __

NOTE: aa B_ c^{chd} _ D_ee would conform to Satin SOP Description for Siamese as well.

Eye Colors

Brown

Blue

Blue Gray

Red (Ruby Eye Whites)

Agouti Rings

This article conforms to Genetics Society of America code standards

Sources:

- Steven D. Lukefahr, Regents Professor, Dept. of Animal, Rangeland & Wildlife Sciences, Texas A&M University-Kingsville
- Amy Hinkle (BS in Biochemistry, MS in Anatomy & Cell Biology) http://www.amysrabbitranch.com/Color%20Guide.html
- Pictures provided by ASRBA from ASRBA Web Site http://asrba.org/