

# Cornsnake Morph Guide

DIGITAL



A Collector's, Breeder's, and  
Buyer's Guide to Morphology,  
Genetics, Pricing, & Identification

*Charles Pritzel*

**2008 Edition**

# Important Notice:

This book is the result of a lot of hard work. It took a lot of time and resources to research and gather existing knowledge, experiment and discover new knowledge, and finally to organize all of it into a useful format. If you wish to say thanks by leaving me a donation, you can send money via paypal to [serpwidgets@hotmail.com](mailto:serpwidgets@hotmail.com), amazon (or other retail) gift card, or bitcoin using the QR code, or email me at [serpwidgets@hotmail.com](mailto:serpwidgets@hotmail.com) to see what other options might be available.

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Thanks, and enjoy!  
Charles Pritzel



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## Foreword

This guide is intended to act as a starting point and a reference, as opposed to an all-encompassing knowledgebase. Once you have a grasp of genetics and a feel for the various generic morphs, the best way to become familiar with the specific looks of the morphs and *all* their variations is to see as many examples of each of them as possible. Internet forums have a lot of pictures, and breeders' websites are another good resource. If you can attend reptile shows, browsing all of the tables and talking to the breeders is another good way to gain additional experience.

Since the “language” of the cornsnake hobby consists almost entirely of slang, you will undoubtedly hear differing usages of the terms in this guide. You'll also hear words that do not appear in this guide at all. The author will attempt to keep up with any common usages within the mainstream of the hobby, and a new edition will be published each year. This year, 2008, is the fifth edition in the continuing series.

This year more test breedings involving the “stargazer” and “short tail” genes are planned. The purpose of including these is not to assert them as “morphs” but to inform readers about any known genes that can affect their breeding results, good or bad.

Given the rising numbers of double and triple genetic morphs, a new chapter on breeding schemes has been added. The method presents one way of easily rolling over these double and triple combinations into quadruple and quintuple combinations.

The recent additions of the dilute, masque, and chestnut genes may be an indicator of a new trend in the hobby: more subtle genetic influences are now being sought out and detected by breeders. This is being helped along by an increase in breeders who are willing to perform breeding trials on odd-looking specimens, and their offspring, to try and prove them as genetic or not. In this spirit, a new chapter explaining test breeding has been added.

***About the “Common Price Index” for morphs:*** This guide includes a “price range” for each morph. The listed prices are included to give the reader a general idea of the current market prices of different morphs. They are calculated using a complex formula designed to determine a reasonable “ballpark” range. By no means are they a suggested price, nor are they necessarily the average.

Note that the prices are based on hatchlings. Lone females are often sold at 10% to 25% more than the cost of a single male because breeders find it more difficult to sell off remaining unpaired males.

Adults and juveniles are usually a lot more expensive than hatchlings, since they will be able to breed sooner. Proven breeders (snakes that have already produced offspring) are even more valuable.

All cornsnakes of the same morph are **not** created equal. Variations in price are based on factors such as:

- how common they are
- how difficult they are to produce
- how popular they are
- local availability
- the quality/distinctiveness of an individual breeder’s bloodline(s) compared to other bloodlines of the same morph
- being het for additional genetic traits

Many morphs can vary wildly in price, in some cases more than twice as much as others of the same morph. Trying to quote prices is like trying to predict the weather six months in advance, so take these numbers with a large grain of salt.

Finding the same morph for a lower price is not necessarily a better bargain... you tend to get what you pay for. Do not assume that any price above the listed range is overpriced. All cornsnakes are unique, and there may be a very good reason for the higher price tag. If you are getting a cornsnake with the intention of breeding it, keep in mind when considering the price tag that this snake’s characteristics will influence the offspring it produces, possibly for generations to come. A few dollars difference may not be such a bargain in that light.

## Types of Morphs

There are three basic ways new morphs can come about:

- Genetic Traits
  - Selective Breeding
  - Hybridization/Intergradation
- 

A **genetic trait** (also known as a “simple” or “Mendelian” or “autosomal” genetic trait) results from a single, identified gene. If the genetic types of the parents are known, a simple set of rules can be applied to predict the ratios of offspring that will express or not express these traits. An advantage of these morphs is that they can be outcrossed (bred to unrelated individuals) and the trait can be fully recovered in future generations.

If you plan on breeding your cornsnakes, it’s a good idea to understand how the rules of inheritance work, what “het” means, and how offspring are labeled. The Genetics chapter and online tutorial (<http://cornguide.com>) are made for that purpose.

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**Selective breeding** (or *line breeding*) is a long-term program and works more like mixing paints together, where a breeder selects offspring that are closest to the desired appearance. For example, you could take the offspring from a clutch and choose those with the longest saddles, and breed them to each other, or mix in other snakes with long saddles. Keep doing this for several generations, and each time the saddles can get longer and longer. This happens because there are a lot of genes affecting this outcome. With each new generation, you are selecting those with more of the desirable genes and less of the undesirable genes than the previous generation.

Outcrossing (breeding to unrelated lines) is like mixing in half a bucket of randomly colored paint, and will generally create offspring who have an intermediate appearance and show varying degrees of the “desired” influence.

This is an important difference from simple genetic traits. When outcrossing a simple genetic trait, you only lose one gene, and need to recover a single “gene pair” in order to completely recover the trait. This is like flipping two coins and trying to get two of them to land on heads, which is a simple matter when you get 10 or more tries... an average clutch size for cornsnakes.

With selectively bred morphs, however, outcrossed offspring will have lost about half of the *many* genes affecting the appearance. In order to recover the original appearance, it is necessary to gather *all* of these genes together again. This is like flipping a lot of coins, and trying to get *all* of them to land on heads. As a result, these looks cannot be recovered so easily after outcrossing.

Selectively bred looks are not the result of any known genes, and their inheritance cannot be accurately predicted. Although a lot of cornsnakes are labeled as “het” for many of these looks, they cannot be properly considered “het” for any selectively bred morph because they are not het for any known gene(s) and there is no assurance that they will breed true with any other cornsnake of the same morph.

That is, when unrelated similar-looking individuals are bred together, the offspring may or may not show the desired “look” that their parents do. This can also happen with related individuals. For example, two “Miami phase” parents will not necessarily throw all “Miami phase” offspring. Keep this in mind when working with selectively bred morphs.

Line breeding is a type of selective breeding. This is where related snakes are bred. They could be siblings, aunts, uncles, cousins, great uncles, etc. The purpose of line breeding is to “fix” a trait, which means creating individuals that *will* “breed true” when crossed to each other.

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**Hybridization/Intergradation** is the process of breeding to another species or subspecies. The term intergrade is generally used to denote a less extreme example of hybridization. For example, when corn breeds to emoryi in the wild, these are considered natural intergrades. When they are crossed in captivity, many consider these intergrades.

Often these offspring are at least partially fertile, and in many cases they are fully fertile, and can produce offspring. Some examples of this have become commonly accepted as “morphs.”

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Additional morphs can be produced through combining these different methods:

- **Genetic trait + selective breeding.** Selectively breeding individuals all having the same genetic trait has produced several new and distinctive morphs. (Candycane, sunglow, etc.)
- **Genetic trait + genetic trait.** Multiple genetic traits can be bred into the same cornsnake. Generally, both traits are expressed at the same time, producing something that looks different than both of the “founding” morphs. Currently, the majority of new cornsnake morphs come from combining genetic traits. (Snow, caramel motley, etc.)
- **Genetic trait + genetic trait + selective breeding.** Selective breeding can be applied to a “genetic combination morph” to exaggerate certain characteristics. (Pink and green snow, etc.)
- **Genetic trait + selective breeding + hybridization.** In the most extreme example so far, selective breeding of intergrades exhibiting a genetic trait has produced new morphs: a “sunglow” variation of the “creamsicle” and a “reverse Okeetee” version of jungle corns.

# Genetics

Many cornsnake morphs are based on simple genetic traits. This chapter is meant to familiarize the reader with the way these morphs come about, how they are reproduced, and a few important terms used to describe them.

For a more in-depth genetics primer, the author has an online genetics tutorial and additional practice problems/answers located at: <http://cornguide.com>

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## *Introduction:*

Don't panic. Genetics seems intimidating at first, but don't forget that counting to a hundred seemed impossible before you learned how to do it. The people who could do it seemed way smarter than you at the time. But then you learned the names and symbols of 0 through 9, a few rules, and practiced a bit. It was frustrating, and sometimes you were convinced you'd never get it. But then, suddenly, it all fell into place and you could count to a million any time you wanted to! The same applies to genetics: a few definitions, a few rules, a bit of practice, and before you know it you'll be comfortable enough to tackle even the biggest genetics problems on your own.

People who can solve genetics problems are not geniuses, they're just practiced. If you can count to a hundred, you too can learn genetics, as long as you're willing to keep going through some frustrating times, and practice practice practice.

---

## *Step 1: The building blocks*



The genetic code of a cornsnake is made of a string of genes, like the above string of symbols. Each symbol represents one gene. Here

we only show a handful, but in real life, cornsnakes have tens of thousands of genes. Below are some different genetic codes of cornsnakes.

Snake 1: 

Snake 2: 

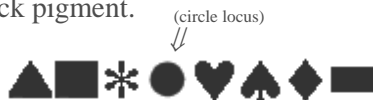
Snake 3: 

Snake 4: 

What cornsnakes have in common is that the order of their genes is the same. Each place in the order is called a *locus*. In our example, we have the Triangle locus, followed by the Square locus, then the Star locus, the Circle, Heart, etc.

Why are all corns similar but not exactly the same? Notice that the loci stay the same but the genes vary from snake to snake.

Each locus holds a gene. Each gene has its own function in the cornsnake. For example, say the Circle locus is where you find the gene that produces black pigment.



As you know, not all cornsnakes have black pigment. The reason is that some of them have a defective copy of the gene normally found at the Circle locus.



Any different genes that can be found at the same locus are called *alleles*. (Allele is pronounced “uh-leel.”) The allele most commonly found at a locus is called normal or **wild-type**.



This is the *normal* or *wild-type* allele for the Circle locus.



This is a mutant allele for the Circle locus.



This is another mutant allele for the Circle locus.



This is the *normal* or *wild-type* allele for the Diamond locus.



This is a mutant allele for the Diamond locus.

There can be any number of alleles for a given locus. In this case, the Circle locus has three, and the Diamond locus has two.

#### *Review:*

- Corns are the same in that they have the same loci.
- Alleles are the different genes found at the same locus.
- There can be many different alleles for the same locus.
- Corns are not identical because they can have different alleles at their various loci.

### *Step 2: Putting the building blocks together*

Each cornsnake has two parents. It gets one full genetic code from each of its parents. This means that every cornsnake has **two** complete genetic codes. That is, each cornsnake has a pair of genes at each locus.

From mother:        

From father:        

Since the parents don't always have the same alleles, the cornsnake can have different alleles paired together. When the pair of alleles are identical, this is called homozygous, which is often shortened to "homo." The above cornsnake is homozygous at the Square, Star,

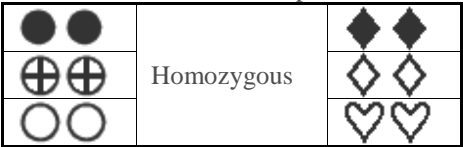
Heart, Spade, and Rectangle loci because the pairs at these loci consist of identical alleles.



When the pair is different, the snake is said to be heterozygous, or *het*, at that locus. The snake is *het* at the Triangle, Circle, and Diamond loci.



Here are some more examples:



*Review:*

- Cornsnakes have two complete copies of the genetic code.
- At each locus, the copies can be the same or different.
- If they are the same, that locus is homozygous.
- If they are different, that locus is heterozygous.

---




***Step 3: The results***

As you just learned, there can be two different alleles paired at the same locus. When that happens, which one controls the appearance of the snake?







This depends on the relationship of the two alleles. Any allele pair is either dominant/recessive, or codominant/codominant.

- In a dominant/recessive relationship, only the dominant allele is expressed. The recessive allele has no effect on the outward appearance.
- In a codominant/codominant relationship, both alleles will have some effect. Sometimes one allele will have more effect than the other. Sometimes their effects are equal. There are many subtle shades of codominance, and they can be subdivided into finer groups. *Incomplete dominance* is one such sub-group, and is discussed with the other advanced genetics topics.

For example, let's look again at the Circle locus. There are three alleles:

	The "Normal" allele produces lots of black pigment.
	The "Albino" allele produces <b>no</b> black pigment.
	The "Semi" allele produces some black pigment, but not much.

With these three alleles, a snake can have any of the following pairs:

<i>Gene pair</i>	<i>Appearance</i>	
	Normal	<i>The normal allele can produce enough for the whole snake by itself. Anything carrying even one copy looks normal.</i>
	Normal	
	Normal	
	Reduced black pigment (hypo)	
	Very reduced black pigment (extreme hypo)	
	No black pigment (albino)	

Notice that ● is dominant to ⊕ and ○. This is true because when ● is present, the other two genes have no effect, the snake is normal. These are dominant/recessive relationships.

Also notice that ⊕ is codominant with ○ because ⊕○ takes on a third appearance, between that of ○○ and ⊕⊕.

*Review:*







- Dominant and Codominant alleles are expressed when present.
- Recessive alleles are not expressed unless they are homozygous.

*Practice: (Answers can be found on page 129.)*

1-If  $\triangle$  (triangle) is recessive to  $\blacktriangle$  (normal) then what do the following snakes look like?

A  	B  	C  
---	---	---

2- If  $\square$  (square) is dominant to  $\blacksquare$  (normal) then what do the following snakes look like?

A  	B  	C  
---	---	---

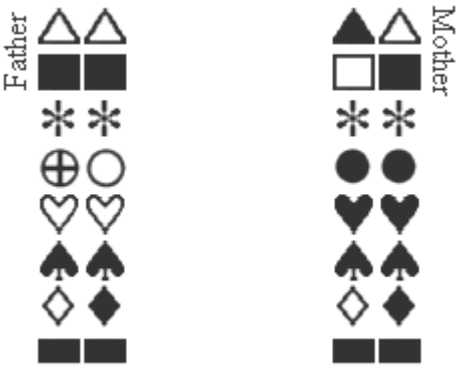
3- If  $\diamond$  (diamond) and  $\blacklozenge$  (normal) are codominant, what do the following snakes look like?

A  	B  	C  
---	---	---

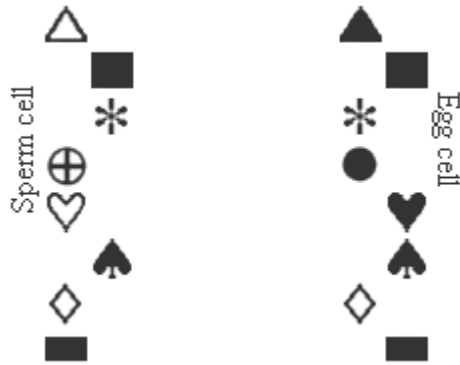
**Step 4: Inheritance**

Now that you know how and why different genes can affect a cornsnake’s appearance, the next step is to understand how an individual cornsnake inherits whichever genes it has.

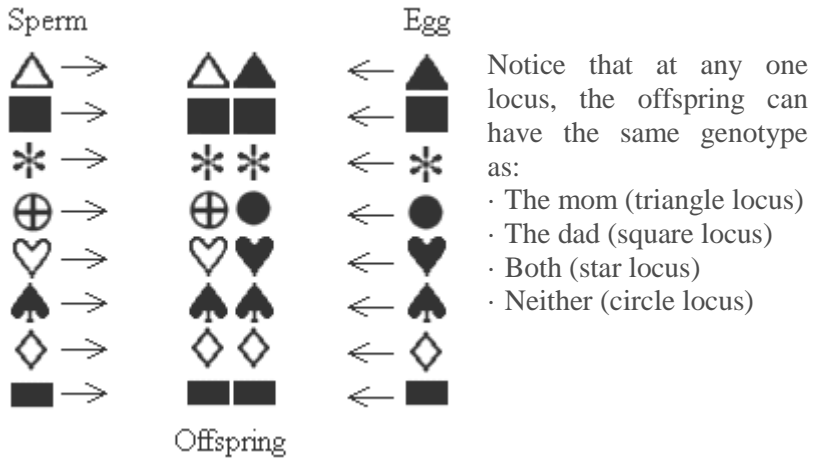
A cornsnake inherits one complete set of genes from each of its parents:



Half of the father's genes are put into each sperm cell. Half of the mother's genes are put into each egg cell. As shown below, each gene may come from either strand.



The sperm cell and egg cell combine to form the new fertilized egg with two complete sets of genes. This egg, known as a zygote, eventually grows to become an offspring. (*Zygote* is part of the terms *homozygous* and *heterozygous*.)



#### Review:

- Each sperm carries half (one from each pair) of the father's genes.
- Each egg carries half (one from each pair) of the mother's genes.



- The zygote (fertilized egg) has half of the father’s and half of the mother’s genes.
  - The zygote has two copies of each gene, just like every other cornsnake.
- 

*Step 5: Predicting offspring*

To simplify things, let’s look at only one locus. At one locus, each sperm can carry one of the father’s two genes, and each egg can carry one of the mother’s two genes. In total, the sperm/egg can combine in one of four ways. As you’ll see, you can use FOIL to remember the four ways. That is:

the **F**irst gene from each parent,  
the **O**utside pair,  
the **I**nside pair, and  
the **L**ast gene from each parent.

It really is that simple. Let’s practice:

Father		Mother	
First	●	○	offspring is → ●○
Outside	●	○	offspring is → ●○
Inside	●	○	offspring is → ●○
Last	●	○	offspring is → ●○

Another one:

Father		Mother	
First	●	●	offspring is → ●●
Outside	●	○	offspring is → ●○
Inside	●	●	offspring is → ●●
Last	●	○	offspring is → ●○

No matter what the symbols are, it's always the same:

Father	● ○	○ ⊕	Mother	
First	●	○	offspring is →	● ○
Outside	●	⊕	offspring is →	● ⊕
Inside	○	○	offspring is →	○ ○
Last	○	⊕	offspring is →	○ ⊕

---

Let's practice again, and look at the results this time. See if you can figure out what the offspring will look like. We'll use the Circle locus again, where ● is dominant to ○ and ⊕, and ○⊕ are codominant to each other.

Father	● ●	○ ○	Mother	
First	●	○	offspring is →	● ○
Outside	●	○	offspring is →	● ○
Inside	●	○	offspring is →	● ○
Last	●	○	offspring is →	● ○

Notice that all offspring are the same. When both parents are homozygous, all of the offspring are the same as each other. When both parents are homozygous for different alleles, like above, all of the offspring are heterozygous because the two genes they have are not the same. These are "known hets" or "100% hets" or just plain "het."

---

Father		Mother	
First			offspring is →
Outside			offspring is →
Inside			offspring is →
Last			offspring is →

Notice that all of the offspring look normal, but half of them are carrying a recessive gene. Since it is not possible to tell which are heterozygous for the recessive allele, and the chances are 50% for each offspring, all of the offspring are considered “50% possible het.” Breeding trials can later prove which are het and not het.

---

Father		Mother	
First			offspring is →
Outside			offspring is →
Inside			offspring is →
Last			offspring is →

Notice that 1/4<sup>th</sup> of the offspring (the ○○ offspring) express the recessive trait. The other three: ●● and ●○ and ○● all look normal. Since two thirds (66%) of these normals are het, they are all considered “66% possible het” or “66% het” because each has a 66.67% chance of being het.

---

Father	● ○	○ ⊕	Mother	
First	●	○	offspring is →	● ○
Outside	●	⊕	offspring is →	● ⊕
Inside	○	○	offspring is →	○ ○
Last	○	⊕	offspring is →	○ ⊕

Notice that the normal offspring (the top two) are het for the recessive ○ or ⊕ allele, but we cannot tell which offspring carries which recessive allele. If those alleles are called “circle” and “cross,” it is customary to label these as “het for circle *or* cross.” In corns, you may run across this scenario when you see labels like “het for ultra or amel” and “het for stripe or motley.”

#### *Review:*

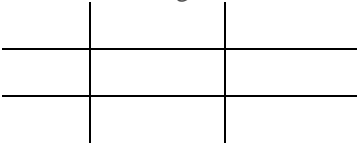
- When the genes of the parents at any locus are known, FOIL can be used to find all possible offspring.
  - When only one parent is het for a recessive allele, and the other parent is homozygous for the dominant allele, the offspring are all “50% possible het” for the recessive allele.
  - When both parents are het for a recessive allele, the normal offspring are all “66% possible het” for the recessive allele.
  - When one parent is homozygous for one allele (●●) and the other parent is heterozygous for two alleles that are both recessive to it (such as ○⊕) the offspring will be het for either one or the other recessive allele.
  - Possible hets are actually either het or not het. This can be proven through breeding trials.
-

**Step 5a: Alternatives to FOIL**

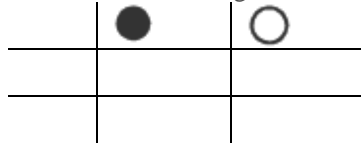
There are many different ways to determine the outcome of a cross at a single locus. FOIL is one of these. Two alternatives are “cross multiplying” and a Punnett square.

A **Punnett square** is made by combining all possible sperm types with all possible egg types. For a single locus, this is always two sperm and two eggs. Just make a tic-tac-toe board, and for the father put each gene in one column on the top, and for the mother put each gene in one row on the left:

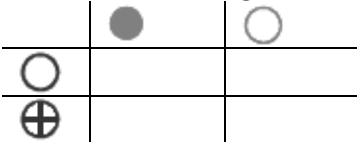
1- Make a 3 x 3 grid:



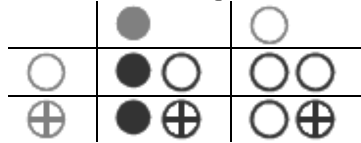
2- Put in the father's genes:



3- Put in the mother's genes:



4- Fill in the four squares.



**Cross multiplying** is performed by laying out the two parents' genes, and then combining each of the father's genes with each of the mother's genes by drawing lines:

<p>1-Father's genes on top, mother's genes below.</p>	<p>2- Combine the father's first gene with each of the mother's genes.</p>
<p>3- Combine the father's second gene with each of the mother's genes.</p>	<p>4- In total, you will get four results, combining each of father's genes with each of mother's genes.</p>

Notice that FOIL, cross multiplying, and Punnett squares all generate the same exact answers. For simplicity's sake, this text refers to FOIL in any instance where the outcome at one locus is calculated. Use whichever method is easiest for you.

### *Step 6: Combining traits*

When more than one locus is involved, FOIL can determine each trait individually. A grid can then be used to determine the combined results. (This technique is similar to Punnett squares, but these are not Punnett squares.)

For this example, we will combine the recessive Triangle trait with the recessive Heart trait to show how a “Triangle + Heart” snake can be created, and to show how the results of the crosses can be calculated.

Start by crossing a snake with the Triangle trait to a snake with the Heart trait:



First, cross the Triangle locus. Use FOIL to get the results:



Then use FOIL on the Heart locus:























Now combine the Triangle results and the Heart results. Since there's only one result each time, there's only one type of offspring:






















These offspring are het at the Triangle locus and the Heart locus. Since they are het at two loci, these snakes are “double het.”

Now, breed these double hets together to make a second generation:
















First, cross the Triangle locus. Use FOIL to get the results.

			x			
F						→  
O						→  
I						→  
L						→  









































Then use FOIL on the Heart locus.

			x			
F						→  
O						→  
I						→  
L						→  

Now create a grid with the Triangle results going across and the Heart results going down:

Then fill in the grid by copying triangles down from the top, and hearts across from the left:





				
	 	 	 	 
	 	 	 	 
	 	 	 	 
	 	 	 	 

Notice that there are 16 possibilities. One of the sixteen (lower left) is homozygous for both recessive traits. The grid above shows how likely each type of offspring is. As with flipping coins or rolling dice, they are only odds. **In real clutches, the numbers of each type will vary from the predictions.**

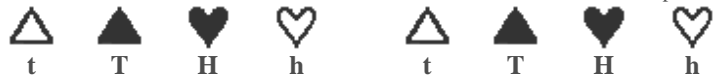
### *Review:*

- A snake het at two loci is double het. Likewise, a snake het at three loci is triple het.
- Use FOIL independently on each trait.
- Combine results for each trait by using a grid.
- Predictions are only the odds of what will happen. Actual results will vary.

### *Step 7: Using Notation*

Drawing and coloring complicated shapes can become a lot of work. Another way to do this is to represent the alleles by using letters instead of pictures. For example, the Heart locus has H instead of  and h instead of . The Triangle locus has T and t instead of  and . Customarily, the capital letters are used to represent the dominant alleles.





In this notation, the previous cross looks like this:  
**tT Hh x tT Hh.**

At the T locus, use FOIL to get: tt, tT, Tt, TT  
At the H locus, use FOIL to get: HH, Hh, hH, hh

Create the grid and fill it in, just like before:

	tt	tT	Tt	TT
HH	tt HH	tT HH	Tt HH	TT HH
Hh	tt Hh	tT Hh	Tt Hh	TT Hh
hH	tt hH	tT hH	Tt hH	TT hH
hh	tt hh	tT hh	Tt hh	TT hh

*Review:*

- Use letters to represent the alleles.
- Generally, the capital letter is used for the dominant allele.

---

**Step 8: Combining Additional Loci**

If you are working with more than two loci, results for a third locus can be added in with the same grid method. Like before, take the first set of results and, using the grid, add the second set to it.

Let’s use results for the D locus where the cross is Dd X dd. We will add these to the previous cross. (The original cross would then become tTHh**Dd** x tTHh**dd**.)

We already have the first two traits figured out. They are the 16 answer squares above.

Next, FOIL the D locus:

- Dd x dd
- F = Dd
- O = Dd
- I = dd
- L = dd

Then use the D locus results going across, and each of the previous 16 (T and H) results going down. Notice that the D locus results can be simplified.

	<b>Dd</b>	<b>dd</b>
<b>TT HH</b>	TT HH Dd	TT HH dd
<b>Tt HH</b>	Tt HH Dd	Tt HH dd
<b>tT HH</b>	tT HH Dd	tT HH dd
<b>tt HH</b>	tt HH Dd	tt HH dd
<b>TT Hh</b>	TT Hh Dd	TT Hh dd
<b>Tt Hh</b>	Tt Hh Dd	Tt Hh dd
<b>tT Hh</b>	tT Hh Dd	tT Hh dd
<b>tt Hh</b>	tt Hh Dd	tt Hh dd
<b>TT hH</b>	TT hH Dd	TT hH dd
<b>Tt hH</b>	Tt hH Dd	Tt hH dd
<b>tT hH</b>	tT hH Dd	tT hH dd
<b>tt hH</b>	tt hH Dd	tt hH dd
<b>TT hh</b>	TT hh Dd	TT hh dd
<b>Tt hh</b>	Tt hh Dd	Tt hh dd
<b>tT hh</b>	tT hh Dd	tT hh dd
<b>tt hh</b>	tt hh Dd	tt hh dd

This method is very easy to do once you've become comfortable with it. Its major drawback is that it can be time consuming when calculating the results of crosses involving 3 or more traits.

#### *Review:*

- Use FOIL independently for each locus.
- Combine results by creating a grid, with one set of results going across, the next set going down.

#### ***Step 9: A Shortcut***

An additional shortcut can be used if you are only interested in determining the chances of one or two particular outcomes. By using FOIL for each locus, you can determine the odds of the desired outcome *for that locus*. The odds at a single locus will always be in quarters: 0,  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , or 1. Multiply the odds at all loci to get the total odds of that outcome.

To multiply fractions, multiply all the top numbers together to get the top answer, then multiply all the bottom numbers together to get the bottom answer. For example,  $\frac{3}{4} \times \frac{3}{4}$  is the same as “3 x 3 over 4 x 4” which is the same as  $\frac{9}{16}$ .

For example, with the above cross **tTHhDd x tTHhdd** usually the main question is “what are the odds of getting **tt hh dd** offspring?”

FOIL the “t” locus to get tt, tT, Tt, TT.

Out of the 4 outcomes, 1 is “tt.”

Your odds are  $\frac{1}{4}$  so far.

FOIL the “h” locus to get HH, Hh, hH, hh.

Out of the 4 outcomes, 1 is “hh.”

Your odds are  $\frac{1}{4}^{\text{th}}$  (from before) times  $\frac{1}{4}^{\text{th}}$  (from this locus) for a total of  $\frac{1}{16}^{\text{th}}$ .

FOIL the “d” locus to get Dd, Dd, dd, dd.

Of the 4 outcomes, 2 are “dd.” Multiply again:

$\frac{1}{16}^{\text{th}}$  times  $\frac{2}{4}^{\text{th}}$  =  $\frac{2}{64}^{\text{th}}$  which simplifies to  $\frac{1}{32}$ .

The odds of getting **tt hh dd** from that cross are 1 in 32 for each offspring. If you count the squares in the grid created earlier, you’ll find the same answer: there are 32 squares, only one of them is **tt hh dd**. This technique is a real time saver, and with a bit of practice, you can do it in your head.

There are also online genetics calculators that will give you the results, but it’s helpful to understand where these results come from before using the calculator. It can also be handy to have a general idea of the expected results without having to run to the computer.

### *Review:*

- Use FOIL independently for each locus.
- Determine how many of the four results at that locus are the ones you want. This is the “answer” for that locus.
- Multiply the answers for all loci together to get one fraction.
- This is the chance *for each egg* to hatch the desired type.

- Remember, these are only odds, and actual clutches will vary. Having 4 eggs with a 1 in 4 chance of hatching the desired type is by no means a sure thing.

### *Step 10: Practice*

Nobody has genetics mastered in the first run through. When you learned something new in school, you had to practice. Likewise, it takes some practice to become comfortable with approaching these problems. Following are some examples that can be used for practice. An answer key is provided in the back of this book. More examples/answers are available at <http://cornguide.com>.

<b>Beginner:</b>	<b>Intermediate:</b>
<i>(Hint: use FOIL)</i>	<i>(Hint: use FOIL on each trait individually, then combine them using a grid.)</i>
1- Cross aa X AA.	5- Cross aaBB X AAbb.
2- Cross Aa X aa.	6- Cross Aabb X aaBb.
3- Cross AA X Aa.	7- Cross aaBb X AaBb.
4- Cross Aa X Aa.	8- Cross AaBb X AaBb

<b>Advanced:</b>
<i>(Hint: use FOIL on each trait, then add in each new trait's results by using a grid.)</i>
9- Cross AABBcc X aabbCC.
10- Cross Aabbcc X aaBbcc.
11- Cross AaBbCC X aabbCc.
12- Cross AaBbCc X AaBbCc.

*With practice, you will find that there are only six basic crosses, and FOIL isn't needed any more once these have been memorized.*

<b>Expert:</b> <i>(Use the shortcut in Step 9.)</i>
13- When crossing AaBbCcDd X AabbccDd, what are the odds of getting the genotype aa bb cc dd?
14- When crossing aabbccdd X AaBbCcDd, what are the odds of getting aa bb cc dd?
15- When crossing AaBbCcDd X AaBbCcDd, what are the odds of getting aa bb cc dd?
16a- When crossing AaBbCcDd X AaBbCcDd, what are the odds of getting anything expressing the recessive a and b traits?
16b- What are the odds of getting anything expressing recessive traits b and c, but <b>not</b> expressing recessive traits a and d?

More practice problems/answers are available in the genetics section at <http://cornguide.com>.

## Advanced Genetics

The topics discussed in this chapter are not necessary in order to understand the breeding or production of cornsnake morphs. The information is presented for those who are curious and want to learn more about genetics topics.

### Shades of codominance

When two alleles are codominant to each other, the appearance of the heterozygotes is different from both of the homozygotes. There are many synonyms for codominant, such as incomplete dominant, semidominant, partially dominant, mostly dominant, etc. What all of these terms have in common is that they specify a relationship where the different pairings of two genes can create *three* distinct phenotypes, as opposed to a dominant/recessive relationship where only *two* phenotypes exist. For all practical purposes, as far as this distinction is concerned, the above terms mean the same thing.

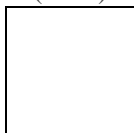
On a more technical level, the third phenotype is sometimes used to further sub-categorize the relationship. It can be a blending of the two looks where both alleles are partially or fully expressed, a mixing where certain parts of the animal fully express one allele and other parts of the animal fully express the other, and many other situations.

When subdividing codominant relationships, the term “incomplete dominant” is used to specify cases where a blending occurs, while “codominant” specifies that both genes are fully expressed in their own separate areas.

(BB)



(WW)

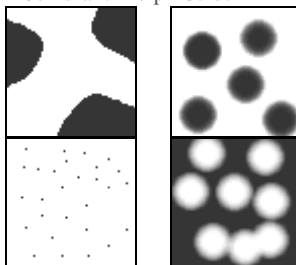


For example, let's take two alleles called black and white. When a specimen is homozygous for the black allele, it is solid black. When it is homozygous for the white allele, it is solid white.

Heterozygous (BW) specimens could have any number of different “third phenotypes.”

The phenotypes on the right could be described as “codominant” since both the black and white genes are fully expressed in their own areas.

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Here are some “shades of gray” examples that would fit the “incomplete dominant” subgrouping.

But this can become an oversimplification. Not all examples fit perfectly into a clear subgroup:

Are the alleles “incomplete dominant” because the phenotype is gray, or codominant because it is made of individual black and white areas? This example could fit both descriptions.




---

Other topics that may someday apply to cornsnake genetics are trait linkage and sex-linked traits. So far, neither of these have been positively identified in cornsnakes. At some point in the future they will, and a discussion of these concepts may prove useful in an effort to identify such traits by their “odd” behavior.

---

## Chromosomes and linkage

Chromosomes are large groups of genes that are physically connected to each other. Because of this, genes that are on the same chromosome will often stay together. This is called linkage. The consequence of this is that linked traits will not “sort independently.”

Independent sorting is like flipping two coins: the way one coin lands has no effect on what the other coin does. They are

independent of each other. A very strong linkage is similar to taping two coins to each other. Now when you flip the two coins, the two results will show a relationship to each other, either always the same or always the opposite.

For example, let's use a simple genome made of two chromosomes. Chromosome 1 has loci A-G, and chromosome 2 has loci H-M.

<i>Chromosome 1</i>	<i>Chromosome 2</i>
a b c d e f g	h i j k l m

Since the chromosomes are paired, each individual has two copies. A specimen's genotype would look something like this:

<b>Chromosome 1</b>	<b>Chromosome 2</b>	
a b c d e f g	h i j k l m	(from mother)
<b>A B C D E F G</b>	<b>H I J K L M</b>	(from father)

When it produces sperm or egg, the chromosomes are split in a few places. This event is known as a *crossover*. The result is that loci on chromosome 1 from mom can be mixed with other loci on chromosome 1 from dad. The results can be chromosomes that look something like this:

a b c <b>D E F G</b>	<b>H I J</b> k l m	<i>Sperm/egg cell 1</i>
<b>A B C</b> d e f g	h i j <b>K L M</b>	<i>Sperm/egg cell 2</i>

Notice that instead of all sperm cells carrying either "cd" or "CD" some of them can carry "cD" or "Cd." These crossovers take place between a few random loci for each sperm/egg cell.

The amount of linkage can vary based on the physical distance between the loci on the chromosome. With a strong linkage, the two loci will almost always be inherited together from the same parent. This can have the effect of making it virtually impossible to combine two recessive traits into the same individual, or virtually impossible to separate two traits that are inherited from the same parent.

For example, let's see what would happen if the Amel and Anery loci were linked. (*This is a hypothetical example. They are not really linked.*) Let's pick a number and say they inherit together 90% of the time. We'll use these symbols:



“A” for the normal allele on the Amel locus,  
“a” for the amel allele,  
“E” for the normal allele on the Anery locus,  
“e” for the anery allele.

Start with an Amel corn and an Anery corn. These would be “aaEE” and “AAee.” When these two are crossed together, each offspring would inherit a chromosome with “aE” from the Amel parent, and a chromosome with “Ae” from the Anery parent.

When you cross these double hets, keep the amel locus and the anery locus together. That is, 90% of the time, the offspring will inherit either “aE” or “Ae.” The two traits together will almost inherit like a single trait. The results are shown in figure 1.

	Ae	aE
Ae	AAee	AaEe
aE	AaEe	aaEE

Figure 1 – Linked double hets where “Ae aE” is crossed to “Ae aE”

The other 10% of the time, the a-locus and e-locus will “cross over.” When this happens, an offspring can inherit either “AE” or “ae.”

In order to be a “snow” (the expression of both traits: anery and amel) an offspring must be “aaee.” For this to happen, it must inherit “ae” from one parent, and “ae” from the other parent.

To illustrate all possible outcomes, the above grid is multiplied by ten. One of the ten copies represents the 10% chance of crossover in each parent. The crossovers create the “AE” and “ae” pairs for each parent.

Ae	Ae	Ae	Ae	Ae	Ae	Ae	Ae	Ae	Ae	AE	aE	aE	aE	aE	aE	aE	aE	ae		
Ae	AAee										AAEe	AaEe								Aaee
Ae																				
Ae																				
Ae																				
Ae																				
AE	AAEe										AAEE	AaEE								AaEe
aE	AaEe										AaEE	aaEE								aaEe
aE																				
aE																				
aE																				
aE																				
ae	Aaee										AaEe	aaEe								aaee

Figure 2 – Results of crossing with 90% linkage between two traits.

Notice that because of the linkage, “ae” will only appear 1 in 10 times. But when a crossover occurs, the opposite pair of “AE” is just as likely to be inherited from that parent. In all, there is only a 1 in 20 chance of inheriting “ae” from each parent, as shown on the bottom and on the right of figure 2. In order to be “aeee” (snow) this “ae” combo must be inherited from *both* parents. Together, the odds of that are  $1/20 \times 1/20$ , or a tiny 1 in 400 chance, as shown by the one square on the bottom right of figure 2. This is quite a difference from the typical 1 in 16 chance that occurs when traits sort independently.

Linkage not only keeps traits apart, it can also keep traits together. If you start with a snow (“aeee”) and cross it to a normal (“AAEE”) the offspring will inherit “ae” and “AE” instead. Notice that the mutant alleles are stuck together this time instead of being stuck apart. As before, 90% of the time the offspring of such a “double het” will inherit both traits together. Almost 1 in 4 of their offspring will express both traits, as opposed to the usual 1 in 16. It will be difficult to separate them.

## Sex-linked Traits

To compare the difference between normal single-locus traits and sex-linked traits, let’s first review the behavior of traits controlled at a single locus on paired chromosomes. (Also known as *autosomal* traits.)

Figure 1 shows the results for an autosomal recessive trait where “A” is dominant to “a.” Like before, FOIL can be used to determine the possible outcomes. Since the “a” mutant is recessive, only “aa” individuals are mutants.

Parents	Cross being performed	Mutant offspring
Normal Normal	$AA \times AA \rightarrow AA$	None
Normal Normal (het)	$AA \times Aa \rightarrow AA, Aa$	None

Normal Mutant	AA x aa → Aa	None
Normal (het) Normal (het)	Aa x Aa → AA, Aa, Aa, aa	25%
Normal (het) Mutant	Aa x aa → Aa, aa	50%
Mutant Mutant	aa x aa → aa	100%

Figure 1 – Results of breedings involving a recessive mutant.

Figure 2 shows the results for an autosomal dominant trait where “a” is the wild-type allele. Only “aa” individuals are normal.

Parents	Cross being performed	Mutant offspring
Mutant Mutant	AA x AA → AA	100%
Mutant Mutant (het)	AA x Aa → AA, Aa	100%
Mutant Normal	AA x aa → Aa	100%

Mutant (het) Mutant (het)	Aa x Aa → AA, Aa, Aa, aa	75%
Mutant (het) Normal	Aa x aa → Aa, aa	50%
Normal Normal	aa x aa → aa	None

Figure 2 – Results of breedings involving a dominant mutant.

Notice that the results do not differ between males and females. Each gender is just as likely to be any of the available genotypes.

The difference between males and females lies in the sex chromosomes, which in snakes are called the Z and W chromosomes. In corns, ZZ = male, and ZW = female. As a result of this difference, certain traits controlled by genes on these chromosomes will follow different rules in females versus males.

The reason for this difference is that there are loci on the Z chromosome that are not on the W chromosome. Since males have two Z chromosomes, the genes will be paired as usual and the trait acts like any other trait in males.

In females, a situation known as “hemizygous” exists. This is when there is nothing paired against the allele on the Z chromosome. It is unpaired because the other chromosome is the W and does not have that locus. As a result, whichever allele is present in a female will be expressed, **even if it acts recessive in males**.

“Lack of function” traits (similar to amelanism) are generally going to be recessive in males, but will **not** be recessive in females.

“Additional function” traits, which would often act like a typical dominant or codominant trait in males, will act somewhat like a dominant trait in females. However, it’s possible in these cases that the males (since they have two Z chromosomes) can receive a “double dose” of the allele where the females cannot. Because of that “double dose,” traits may show more extreme expression in males than females. It’s possible that this is the situation causing the pinkish colors on some anerythristic males, and/or the differences between male and female hypo lavenders.

In addition to the actual expression of the traits, the inheritance patterns will not be the same as usual. The following rules apply to sex-linked traits:

- 1- The female passes her W chromosome to all of her daughters.
- 2- The female passes her Z chromosome to all of her sons.
- 3- If a female is expressing a Z-based trait, it was inherited from her **father**. (Remember, she got the W chromosome from her mother.)
- 4- Females **cannot** pass any Z-based traits to any of their daughters.
- 5- Males can pass a Z-based trait on to their daughters or their sons.

These rules lead to some interesting consequences involving the way these traits will be distributed in hatchlings, depending on which parent(s) are carrying which alleles.

If we use a small z to show the sex chromosome carrying a recessive mutant, the expected results are shown in Figure 3.

Parents	Cross being performed	Mutant offspring
Normal male Normal female	$ZZ \times ZW \rightarrow ZZ, ZW$	None
Normal male Mutant female	$ZZ \times zW \rightarrow Zz, ZW$	None
Normal (het) male Normal female	$zZ \times ZW \rightarrow zZ, ZZ, ZW, zW$	Females (50%)
Normal (het) male Mutant female	$zZ \times zW \rightarrow zz, Zz, zW, ZW$	Females (50%) Males (50%)
Mutant male Normal female	$zz \times ZW \rightarrow zZ, zW$	Females (100%)
Mutant male Mutant female	$zz \times zW \rightarrow zz, zz, zW, zW$	All offspring

Figure 3 – recessive Z-linked trait.

In figure 4 we explore the results expected from a dominant Z-linked trait. This time, the bold Z represents a dominant mutant.

Parents	Cross being performed	Mutant offspring
Normal male Normal female	$ZZ \times ZW \rightarrow ZZ, ZW$	None
Normal male Mutant female	$ZZ \times zW \rightarrow ZZ, ZW$	Males (100%)
Mutant (het) male Normal female	$zZ \times ZW \rightarrow zZ, ZZ, ZW, zW$	Females (50%) Males (50%)
Mutant (het) male Mutant female	$zZ \times zW \rightarrow zz, Zz, zW, ZW$	Females (50%) Males (100%)
Mutant male Normal female	$zz \times ZW \rightarrow zZ, zW$	All
Mutant male Mutant female	$zz \times zW \rightarrow zz, zW$	All

Figure 4 – dominant Z-linked trait.

If the trait is codominant, there will be three phenotypes in the males, as usual. However, since there are only two possible genotypes in the female, there would only be two phenotypes in the females.

## Allelic Mutations







Current data from the results of breeding trials indicate that the gene known as “ultra” is an *allele* to Amelanism. It is also believed that the motley and stripe mutants are alleles to each other. (See Genetics chapter to learn about alleles.)

Since this concept is often confusing to people who have only had to deal with simple-recessive genetics, this chapter explains the consequences of allelic mutants in detail. It cannot be explained or understood in the terms of simple-recessive genetics. It is necessary to have a grasp on basic genetics (including the true meanings of locus, allele, and het) before the information here can be properly absorbed. **If you do not understand the meanings of *locus* and *allele*, this chapter will be meaningless.**

To start off, let’s look at how amelanism has been known to work. There are two alleles that were known to exist at the “Albino” locus: normal and amel.

Allele	Symbol	Max Melanin Production
Normal	●	100%
Amel	○	0%

When these 2 alleles are paired in the 3 possible combinations, we get the familiar results:

Gene Pair	Max Melanin production	Type
 (100)  (100)	200%	Normal
 (100)  (0)	100%	Normal (het amel and normal)
 (0)  (0)	0%	Amelanistic

Notice that anything with 100% or more “max melanin production” is normal. This isn’t how much of the dark pigment it *does* produce, just how much it *can*.

Now, enter another mutation of the “●” gene at this locus, but this one can produce 25% of the normal amount of melanin. We’ll call it “ultra.”

Allele	Symbol	Max Melanin Production
Normal	●	100%
Amel	○	0%
Ultra	⊕	25%













When these 3 alleles are paired in the 6 possible combinations, we get a different set of results:

Gene Pair	Max Melanin production	Type
● (100) ● (100)	200%	Normal
● (100) ○ (0)	100%	Normal (het amel and normal)
● (100) ⊕ (25)	125%	Normal (het ultra and normal)
⊕ (25) ⊕ (25)	50%	“Ultra”
○ (0) ⊕ (25)	25%	“Ultramel” (het ultra and amel)
○ (0) ○ (0)	0%	“Amel”

Notice that two new morphs are now possible. These are the “ultra” which has about half the normal amount of melanin, and the “ultramel” (short for Ultra/Amel) which has only about a quarter as much dark pigment.













The other important point to remember about allelic mutations is that crosses involving two different mutant alleles will have results that will seem odd to those who haven't worked with allelic traits. It may seem complex at first, but it will become familiar soon enough.

Here are some sample crosses to demonstrate the results that differ from previous traits.

Amel X Ultra		
	  Ultramel	  Ultramel
	  Ultramel	  Ultramel













As you can see, the offspring all inherit one amel and one ultra. These are "ultramel" hatchlings.

---

Amel X Ultramel		
	  Ultramel	  Amel
	  Ultramel	  Amel













This time, half are ultramels, half are amels.

---

Ultra X Ultramel		
	  Ultra	  Ultramel
	  Ultra	  Ultramel

Another split clutch, but this time the two results are ultramels and ultras.




---

Ultramel X Ultramel		
	  Ultra	  Ultramel
	  Ultramel	  Amel

This clutch contains amels, ultras, and ultramels.

---



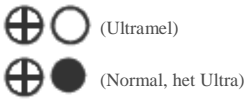
Ultramel X Normal		
	  Het Ultra	  Het Ultra
	  Het Amel	  Het Amel

Notice with this last clutch that you are crossing a morph to a normal, and it is **not** true that the offspring are het for what the morphed parent is. Notice that half are *only* het for ultra, the other half are *only* het for amel. The difficulty many hobbyists have with this concept is not because the rules have changed, but that the slang usage of “het” (to mean “carrying a hidden gene”) was inaccurate, and is now insufficient.

Another very important point is that amelanistic cornsnakes cannot be het for ultra, **no matter what their parents are**. An amel corn is always this gene pair:






To be het for ultra, a cornsnake must be one of these two types:



The trick is that “het” has long been associated only with normal looking snakes, but that was only a coincidence. This is because until recently, only simple recessives were being dealt with. An ultramel cornsnake is, in fact, heterozygous. It is “single het” for ultra and amel. (It is not “double het” because it is only het at one locus.)

Motley and stripe share the same locus as each other. This creates a similar situation.

Allele	Symbol
Wild-type	
Motley	
Stripe	

The main difference is that it appears stripe is recessive to motley, as opposed to the two mutants being codominant to each other. Given the two mutants and the wild-type gene, there are 6 possible genotypes.

Gene Pair	Result
● ●	Wild-type pattern
● ⊙	Wild-type pattern (het motley)
● ⊕	Wild-type pattern (het stripe)
⊙ ⊙	Motley pattern
⊙ ⊕	Motley pattern (het stripe)
⊕ ⊕	Stripe pattern

Note that since stripe is recessive to motley, it is possible for a snake with the motley pattern to carry the stripe gene.

It is also possible for two motley-looking snakes to produce striped offspring.

Motley het stripe X Motley het stripe	⊙	⊕
⊙	⊙ ⊙ Motley	⊙ ⊕ Motley
⊕	⊕ ⊙ Motley	⊕ ⊕ Stripe

When a motley het stripe is crossed to a normal, the offspring are het for either stripe or motley.

Motley het stripe X Normal	●	●
⊙	⊙ ● Het Motley	⊙ ● Het Motley
⊕	⊕ ● Het Stripe	⊕ ● Het Stripe

### Conclusions:

In order to deal with the latest discoveries and continue using genetics to understand cornsnake traits, it is now necessary to drop the old slang usage of “het” to mean “a carrier of a hidden gene,” and instead utilize the concepts of locus and allele, along with a real definition of het: a gene pair consisting of two different alleles.

## Normal Cornsnakes

In order to understand what variations there are, it is necessary to be familiar with the normal appearance of cornsnakes, including natural variations on the theme.

A normal cornsnake pattern is composed of three pigments:

- Melanin – **Mel**-uh-nin, this produces the browns and blacks.
- Erythrin – **Air**-ee-thrin, this produces the reds and oranges.
- Xanthin – **Zan**-thin, this produces the yellows.



- The dorsal pattern consists of red saddles.
- The saddles are outlined in black.
- The ground color is anywhere from light gray to tan to orange.
- Starting from the edge of the belly to varying points on the side, there are generally one or two rows of side blotches.
- Often the blotches on the side are connected to either the dorsal saddles, or the lower blotches.
- Yellow pigment often grows in during the first year or two after hatching. It will be most visible on the sides of the jaw and neck.
- Two longitudinal stripes, generally a gray or “dirty” color, can appear along the length of the snake, at about the ten o’clock and two o’clock positions on the back.
- Two additional dark longitudinal stripes can appear, one along the middle of each side.
- The belly is similar to a basic black and white checkerboard pattern. Some color, usually red or a light red/tan, can wash over the white parts of the belly.
- A “blush” color in the cheek area. This is from blood supply instead of a pigment, and thus it is present in all cornsnakes.

Hatchlings will start out with very little of the red, yellow, and orange coloration. To many beginners, hatchlings look like anerythristics or some “odd morph.” The saddles will be a deep burgundy or brown, and the ground color is in shades of gray or tan, with orange “dots” of color visible between the saddles, especially on the neck. The colors generally reach their peak when the snake is about 3 feet long.

There are many variations on this basic “normal” theme, all of which are still considered normal. They include, but are not necessarily limited to:

- Longer, shorter, wider, or thinner saddles.
- Fading out of two areas inside the saddles, one on either side.
- Fading out of a large area in the middle of the saddles.
- A few saddles being offset or smashed together, forming a **U** or **S** or **Z** or **W** shape.
- Thicker or thinner borders around the saddles. (Thinner borders can be gray instead of black.)
- White stippling around the outside of the black borders.
- Absent or more prominent “dark” longitudinal striping. This can also turn a light gray in adult cornsnakes.
- A great deal of variation of “general darkness” in the overall colors of the snake can be found among normals.
- Some belly checkers missing or bunched up.
- Belly checkers fading to brown, light tan, or reddish tan.
- A “stripe” of white running down the center of the belly.
- Freckling or a red wash across the belly, especially near the tail.
- Slight blurring/smudging of the lateral pattern, compared to the dorsal pattern.

The following are just a few examples of the wide variation to be found in normal cornsnakes.



*White Stippling  
around saddles*



*Two saddles almost joined*

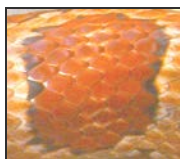


*Offset or joined  
saddles*

Some breeders select away from the white stippling around the saddles, as opposed to breeding for it.

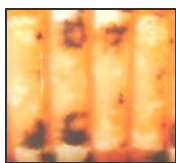


*Dark longitudinal striping is especially  
more apparent during shed cycles*

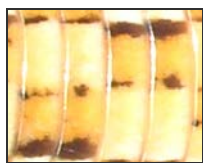


*Faded areas on  
sides of saddles*

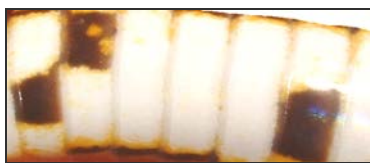
Note that many breeders select away from the dark striping and dirty overwash of melanin, so this look is slowly becoming less common in the general population.



*Belly with clear  
center*



*Faded Belly  
checkers*



*Missing belly checkers*

Keep in mind that the same amount of variation is possible in each of the color and pattern morphs, too.

Additionally, males and females in many lines exhibit *dimorphism*, where the males are an overall lighter color, have more of a general wash of oranges/pinks, have thinner border areas, and are more prone to the “white stripe” on the belly where the checkers do not meet. These differences are usually more obvious in anerythristics and lavenders, and many bloodreds, but can also be observed in normals and virtually every color/pattern morph.

## Head Patterns

There is a great deal of variety in the head patterns of cornsnakes. Although this is generally not considered a major part of cornsnake patterns, colors, or genetics, these variations can be fascinating on their own. Some of the variants appear to be inherited like simple genetic traits.

It is hoped that the new registry will be an extremely useful tool in studying head patterns, and trying to determine their modes of inheritance.

- The basic arrowhead blotch is a “key.” The key can be modified in several different ways.



- The lines that connect the different parts (top, middle, bottom) can be broken on one or both sides.



*“Tulip” patterns (left) can be formed by a missing center. “Smiley” and “deadbolt” patterns (right) can result from breaks between the middle and the top.*

- The top, center, or bottom of the blotch can be enlarged. This “crowning” tends to create points along the edges of the blotch.



*Many “club” type patterns come from enlargement of the whole blotch. Notice the crowning points on each.*

- The top, center, or bottom of the head blotch can be connected to the outside of the head pattern. This can come in the form of a complete connection, or just a tendency in that direction.



*The “ringneck” (found in a lot of striped corns) connects to the outsides along the back end of the blotch. Connections can be made from the middle of the key, the upper sides, or the top.*



*This example shows five common places where the central blotch connects to the outside:*

*1- Top center.*

*2 & 3 – left and right upper connectors, in this example connected on the left side.*

*4 & 5- left and right middle connectors, in this example extended on the right.*



Between these five, and the two where the “ringneck” is formed, there are a total of seven main connecting positions.

- In more extreme examples, often found on corns expressing the diffused or masque patterns, a shape like a skull is apparent. It is often called a “scream” pattern because it resembles the white mask in the “scream” movies. Generally, the top point is connected, along with two pairs of points from the upper side, and the center. These leave only two oval-shaped spots.



*(Left) Skull patterns on “pewter” and “bloodred” specimens.*



*(Right) Incomplete connection of the center can leave a heart shape.*

Some head patterns are not as easy to classify. The first and second examples below (“twig and berries”) look to have a key with a broken center. The other two below, like the head patterns of many sunkissed corns, seem to defy the usual descriptions.



Some head patterns appear to be more common in certain morph types. This may or may not be a good indicator of the ancestry of a cornsnake, so in most cases it’s not a good idea to use it as a method of identification. So far, very little work has been done on the inheritance of head patterns.



## Eye Colors

The eye color consists of the iris color and the pupil color. The iris color is determined by the same pigments that form the skin colors. Generally eye color tends to match that of the saddles, but in some specimens it can tend toward, or even match, the ground color. If red or yellow pigments are present, the eyes will usually take on that coloration as the pigments grow in. In normal specimens the eyes will start out reddish-brown and then slowly turn to orange/red as the snake grows up. If only melanins are present in the iris, the color scale goes from black where the most pigment is present, and turns to brown, tan/silver, and then blue when very little melanin is present. Morphs where blue eyes have been observed include ghosts, phantoms, lavenders, hypo pewters, and neonate ultramels.

The pupil color is controlled by melanin content in the retina, which is normally supposed to be dark enough to absorb all incoming light. When it doesn't, the light bounces around inside the eyes and can decrease visual acuity. Generally the pupils are black, but when melanin becomes scarce enough, the blood supply present in the retina will cause the pupils to become a ruby color. In some lines of hypo and ghost corns this occurs often. Lavenders, and especially ultramel corns and hypo lavenders will generally have ruby pupils. The few known hypo pewters also have ruby pupils.

In specimens that have reduced retinal melanin but not enough to make the eyes appear ruby, shining a bright light into their eyes will be enough to see the ruby color, too. Some lavender specimens that normally have black pupils will fall into this category.

In the total absence of melanin, the pupils are a bright red or pink color. This is true of amelanistic-based morphs, and is also seen in lava lavenders.

In other species there are specific genes known to control pupil color independently of skin color, but no such genes have been demonstrated in corns to date. A “ruby-eyed” and/or “pink-eyed” gene that controls the eyes independently from the skin color could someday be located. Until such a gene is proven out, it is assumed that the lines of hypos and ghosts which exhibit ruby eyes are simply the result of slightly less retinal melanin than their black-eyed counterparts.

## Selectively Bred Variations

Note that only the most common selectively-bred morphs are covered here. It is possible to select for any particular set of characteristics and many breeders have their own distinct lines. Just because a morph is not covered here does not mean it has not been honed by a breeder to bring out certain traits.

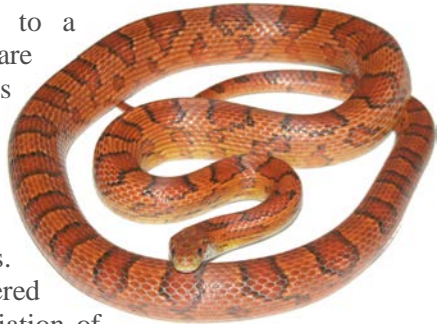
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### **Okeetee (Okeetee Phase) (\$30-\$60)**

Pronounced “Oak-uh-tee.” There are two main uses of this word:

The original meaning refers to a locality, and some people are interested specifically in corns from this locality. The stereotypical Okeetee corn has extremely bright orange and red colors separated by thick, bold black borders.

Okeetees are generally considered the most attractive natural variation of cornsnake, but not all specimens from this area match the description. They are also referred to as *Hunt Club Corns* or *True Okeetees*, in an effort to distinguish them from the second type. The Registry may help track lineage of these animals to retain locality information.



Another meaning has branched off from this, and is perhaps more common than the original. It refers to corns having the stereotypical “look” of Okeetee locality corns. Many of these have been produced from various bloodlines. They will have some, little, or no connection to any corns from the actual locality. They are also sometimes referred to as “look-eetees” or “Okeetee Phase” in an effort to ensure the buyer doesn’t assume they are locality corns. Cornsnakes cannot be het for Okeetee or Okeetee Phase.

### **Sub-varieties of Okeetees:**

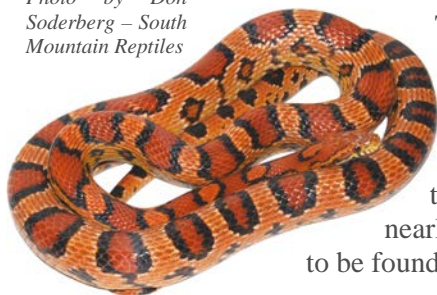
Many breeders have a special admiration for Okeetee corns and have been breeding them to improve upon the wild-type Okeetee look. The two most well known are Kathy Love's Okeetees, and Lee Abbott's Okeetees.



*Photo by Bill & Kathy Love – Cornutopia.com*

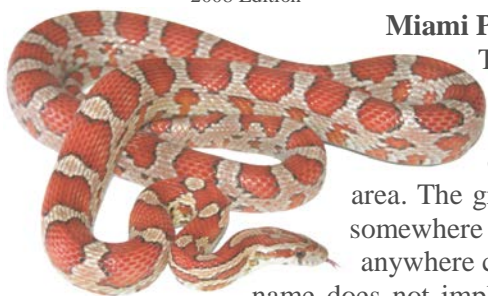
The **Love's Okeetees** tend to stand out from wild-type Okeetees in several ways. Kathy has succeeded in breeding out the dark longitudinal striping. The "holes" inside the saddles have been removed so that the saddles are one solid color, and the white stippling around the saddle borders is absent or reduced. The other distinctive quality of Love's Okeetees is that each color on the snake is extremely smooth, instead of being speckled.

*Photo by Don Soderberg – South Mountain Reptiles*



The **Abbott's Okeetees** are most well known for the extreme thickness of the black bordering. In some examples, the saddles near the tail end of the snake are solid black or nearly so, with little or no red color to be found inside the borders.

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### **Miami Phase (\$25-\$45)**

The name “Miami phase” was coined to describe a look that is often found in corns coming from that area. The ground color is gray, tan, or somewhere between. Cornsnakes from anywhere can take on this look, so the name does not imply a locality, nor does any corn coming from that area automatically qualify as a “Miami phase.” Hatchlings have a clean gray ground color. Individuals with the least traces of orange on the neck tend to generally turn out with the cleanest gray ground colors as adults. Cornsnakes cannot be het for Miami phase.

### **Upper Keys corn, Keys corn, Rosy Ratsnake (\$30-\$50)**

Cornsnakes from the Florida Keys used to be classified as a separate subspecies.

They tend toward an overall lighter appearance, similar to hypos. The belly checkering is generally not as strong, or is even absent. The ground color tends more toward shades of tan, and there is generally less contrast

between ground and saddle colors. The black borders around the saddles are less prominent than in typical corns, or entirely absent. Cornsnakes cannot be het for “upper keys” or “rosy ratsnake.”



*Photo by  
Russell Keys*

### **Kisatchie, *Slowinskii* (\$70-\$80)**

These come from certain areas of Louisiana and Texas, and are thought by many to be an intergrade of cornsnakes and emoryi ratsnakes. The new classification, which separates *Elaphe* into *Pantherophis*,



*Photo by Don Soderberg –  
South Mountain Reptiles*

considers them a separate species: *Pantherophis slowinskii*. Colors are in dark browns and grays and can look somewhat like very dark anerythristics. Cornsnakes cannot be het for Kisatchie.

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### **Milksnake Phase, Banded** (\$40-80)

Banded cornsnakes have been bred to have wide saddles, or saddles which connect to the side blotches for a banded look.

The milksnake phase lines are intended to resemble eastern milksnakes. They were started with Miami corns, and as a result tend to have a light/clean ground color. Milksnake phase corns have also been crossed into motley lines. Carol Huddleston is investigating to see if they are in any way related to sunkissed motleys, since some of these retain checkering combined with a motley-like appearance.

Cornsnakes cannot be het for milksnake phase, or banded.

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### **Aztec, Zigzag** (\$40-\$55)



*Partial zigzag pattern*

The zigzag pattern results from the left and right sides of the saddles being offset from each other, creating a “zipper” type of pattern. This can occur on anywhere from a single saddle to all saddles. Generally a snake is not considered a zigzag unless 80% or more of the saddles are zigzagged. Specimens with less are often called “partial zigzag” or “partial aztec” instead.



*Aztec pattern*

Aztec is an aberrant pattern that often has small pieces of colors strewn about, as if the saddles were made of glass and had been shattered. As with zigzags, a little, some, or all of the pattern may be affected, and individuals with a large amount of the aberrant aztec pattern are valued.

Some individuals will show both zigzag and aztec type patterning. Individual cornsnakes can show varying degrees of either of these patterns, and both types can mix and meld between one and the other, so there is plenty of gray area between what is considered zigzag and what is considered aztec.

Selective breeding of the most extremely patterned individuals generally creates the most extremely patterned offspring. These are very unpredictable patterns. Sometimes crosses – even between parents with the best patterns – produce normally patterned offspring. In other cases, normally patterned parents can produce extremely odd patterned offspring.

Cornsnakes with aztec or zigzag parents are commonly listed as “het” for zigzag or aztec. Do not assume they will produce these patterns in the same way as proven genetic traits do.

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#### *Other variations...*

Many breeders selectively breed to establish certain looks in their own lines. When they are satisfied that a line is sufficiently different to warrant a name, they will apply one.

On the other hand, some breeders or resellers will simply apply a name in order to try to sell their product more easily, because it implies that the snakes are “special.”

Do not assume that a cornsnake with an unrecognized name is automatically special, but don’t assume it is a scam either. If you think they would be a good addition to a breeding project, ask the breeder some questions, such as:

- What is special about the individuals with that name?
- How were they produced?
- Are there any known genetic traits involved?
- Do they “breed true?” (If I breed two of these together, will the offspring look like these?)
- Are there any other unusual or notable tendencies (good or bad) in that line?

Someone who has worked hard on a project will have a lot to say about them. Someone who has simply attached a name in order to sell something will not have much to say.

Either way, that type of corn still may be a good addition to your projects, but it's helpful to have as much information as possible about what you are working with.

## Genetic Morphs

To understand all of the genetic traits involved in corn morphs, it is vital to know how *all* types of traits work, not just recessives. The genetics chapter in this book is highly recommended reading for anyone wishing to learn how all of these traits work.

Morphs are organized by locus, with selectively-bred and genetic combination morphs appearing in those sections.

**Readers unfamiliar with the terms *locus* and *allele* need to familiarize themselves with these concepts in order to work with genetic cornsnake morphs.** Many hobbyists continue to practice and teach pseudogenetics, especially in other species. Any explanation of genetics that does not include these terms is insufficient to deal with the reality of cornsnake traits as they are known today. Again, the genetics chapter in this book covers all you need to know, and the web tutorial is an additional resource.

Example pictures should not be used as an absolute standard or identification method. Some traits will mimic each other -- such as charcoal and anery, and ultra and hypo -- so a visual identification may be insufficient. Just because your snake looks more like the ultra picture than the hypo picture, does not mean your snake is an ultra. When the specific gene is unknown, breeding trials are necessary.

### *Common Names:*

While all genetic combination morphs can be identified by a listing of the genetic components, a few morphs are sometimes called by a more fanciful name. These common names or "trade names" are not intended to be an exact description of the morph, but to present a more "artistic" version. Some are more commonly applied than others.

**Snow** – amel, anery

**Blizzard** – amel, charcoal

**Butter** – amel, caramel

**Opal** – amel, lavender

**Ghost** – hypo, anery

**Phantom** – hypo, charcoal

**Amber** – hypo, caramel

**Topaz** – lava, caramel

**Pewter** – charcoal, diffusion

**Ice** – lava, anery

**Granite** – anery, diffusion

**Golddust** – ultra/ultramel, caramel

**Fire** – amel, diffusion

**Avalanche** – anery, amel, diffusion

**Whiteout** – charcoal, amel, diffusion

**Sulfur** – caramel, amel, diffusion

**Plasma** – diffusion, lavender



The Albino locus:

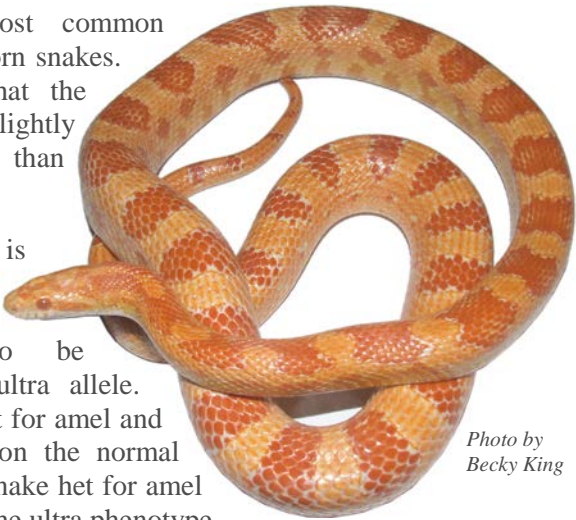
Allele	Name
A <sup>+</sup>	Wild Type
a <sup>a</sup>	Amelanism
a <sup>u</sup>	Ultra

Genotype	Known as:
A <sup>+</sup> • A <sup>+</sup>	Wild type
A <sup>+</sup> • a <sup>a</sup>	Wild type (Het Amel)
A <sup>+</sup> • a <sup>u</sup>	Wild type (Het Ultra)
a <sup>a</sup> • a <sup>a</sup>	Amelanistic
a <sup>a</sup> • a <sup>u</sup>	Ultramel (single-heterozygous for Ultra/Amel)
a <sup>u</sup> • a <sup>u</sup>	Ultra

**Amel**, aka **Amelanistic**, **Albino**, **Red Albino**. (\$20-\$35)

Amel is the most common mutant found in corn snakes. It is estimated that the amel allele is slightly more common than wild-type.

The amel gene is recessive to the wild-type allele, and appears to be recessive to the ultra allele. That is, a snake het for amel and normal will take on the normal phenotype, and a snake het for amel and ultra takes on the ultra phenotype.



*Photo by  
Becky King*

As its name suggests, when amelanism is expressed, melanin (the black/brown/gray pigment) is absent. Areas where black would normally appear will instead be white, yellow, pink, or even “greenish” looking. Some amels hatch out with little to no color and nearly resemble snows. So far, specimens hatching like this have turned into typical-looking amels within a few sheds.

Amels are most easily identified by their eyes. The eyes are a distinctive glowing red/pink, except for a small dark spot toward the

front of the eye. If the pattern of the snake is one where belly checkers are expected, the “black” areas on the belly should instead be a clearish flesh color, or a shade of yellow/orange/red.

## Selectively-bred variations of Amel:

### Sunglow, “No-white Amel” (\$40-60)

The idea is to remove all traces of white, and to get a bright orange ground color. This creates a very bright red and orange cornsnake.



*Photo by Bill & Kathy  
Love – Cornutopia.com*

Some breeders use hypomelanistic corns as a starting point, since many hypos have thinner borders. The motley pattern (used to create sunglow motleys) also tends to reduce the border thickness and get rid of a lot, or all, of the white. The

diffused and striped patterns have also been used to augment the sunglow look. Some sunglow offspring will start out with white borders, which will then fade out as they mature. Amelanistic cornsnakes cannot be het for this look.

### Candycane (\$50-60)

The idea is to remove the oranges and yellows from the ground color, leaving red saddles on a clean white background with striking contrast.

*Photo by Russell Keys*



Any ground color is undesirable in this morph, so they tend to resemble an amel version of the silvery Miami phase normals. Candycanes are often divided into two

types, red and orange. The red or orange refers to the saddle color, and **not** the ground color. A “candycane with orange ground color” would be a regular amel.

Since the yellow and orange ground color grows in as cornsnakes mature, some clean-looking candycane hatchlings can grow up to look less than ideal. It is not possible to predict with 100% accuracy which ones will do this as they grow up. But as a general rule, the

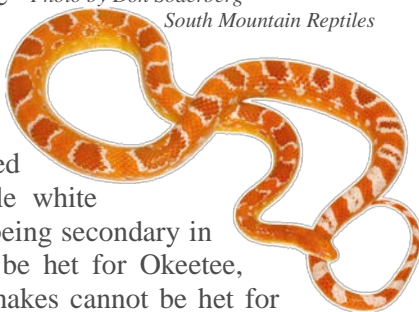
hatchlings with the least amount of yellow or orange ground color, especially on the neck, will tend to grow into more ideal candycane adults. An amelanistic cornsnake cannot be het for candycane.

### Reverse Okeetee, Amelanistic Okeetee, Albino Okeetee (\$40-50)

The use of the name “Okeetee” with this morph does not imply the Okeetee *locality*, just a look. A stereotypical Okeetee corn has bold borders on bright colors. The amelanistic version still has the bright orange ground color and red saddles, but the wide black borders have been “reversed” to white. These are often bred mainly for the thickest possible white borders, with the ground color being secondary in importance. No cornsnake can be het for Okeetee, and likewise, amelanistic cornsnakes cannot be het for reverse Okeetee.

*Photo by Don Soderberg –*

*South Mountain Reptiles*



### Genetic Combinations with Amel:

**Amel + Hypo** – (\$40-60) Hypo’s effect on the coloration appears to be masked by the amel trait. Since hypo also has a mild effect on the patterning, it may affect amels, but to date nobody has presented a reliable way to visibly separate these from regular amels.



*Photo by  
Becky King*

**Amel + Sunkissed** – (\$???) Sunkissed Amels have so far displayed the expected combination of the sunkissed pattern drawn in the colors of an amel. However, only a small number of specimens exist at this time.





*Photo by Russell Keys*

**Amel + Lava** – (\$???) “Lavamel” appear to be a brightened version of amels with more of the saturated reds/oranges. It is unclear at this point how much of the difference is caused by the lava gene versus selective breeding.

**Amel + Anery** – (\$25-45) **Snow** is one of the most common double morphs. As hatchlings, saddles are pink on a white background. If saddle borders are present, they will appear “clear” and can develop yellow or mild “green” colors. As they mature, the saddle colors can fade in contrast, or turn a more pastel orange-like color.



Between these and the yellows and pinks and “green” hues, snow corns can be very colorful. (See “Pink & Green” and “Coral” snows, Page 72)

**Amel + Charcoal** – (\$50-70) **Blizzard** corns are similar to snows, but generally have a less noticeable pattern and nowhere near as much color. The saddles are a pinkish white. Hatchlings and some adults can appear virtually patternless. Yellow rings sometimes grow in around the saddles.



**Amel + Caramel** – (\$35-70) As hatchlings, **butter** corns can sometimes resemble snows or amels.



*Photo by Sean Niland – VMS Professional Herpetoculture*

Butters can range in appearance from almost “snow-like” to almost “amel-like.” Saddle colors tend to range from yellow to a dark brownish orange, and the ground color ranges from white or off-white to shades of yellow.

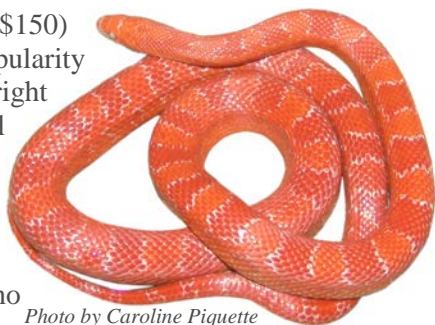
**Amel + Lavender** – (\$75-100) *Opal* corns somewhat resemble snow and blizzard corns. In some, the ground colors are more colorful than the saddles, which can be almost white, and they look like a snow corn with the colors reversed. Others can be as low contrast as blizzards. As with other lavenders, a wash of orange/pink can be present, especially in juveniles.



*Photo by Sean Niland – VMS  
Professional Herpetoculture*

**Amel + Diffused** – (\$80-\$150)

*Fire* corns are gaining in popularity for those who enjoy bright amelanistic corns. Several breeders are working to improve “sunglow” corns by adding bloodred lineage into the morph. Some grow up to have very little or no white flecks.



*Photo by Caroline Piquette  
–Breeding Colors*

**Amel + Motley** – (\$30-60) Many of these tend to be very bright amelanistics, and are also known as “*sunglow motley*” when the ground color is a bright orange and white is absent. Candycane motleys are being bred but are less common than sunglows.



**Amel + Striped** – (\$50-70)

Like amel motleys, striped amels tend to be very bright in coloration. A line of sunglow stripes also exists. Candycane stripes are still unknown at this time.



*Photo by Kat Hall –  
Corn Quest*





**Amel + Cinder** – (\$???) Carol Huddleston hatched out this combination in 2005. This morph should give a good indication of how much red is to be expected in corns expressing the cinder trait.

*Photo by Carol Huddleston –Low Belly Reptiles*

## **Ultra and Ultramel** (short for “Ultra/Amel”) (\$50-120)



Ultra is the next mutant allele to be discovered at the amel locus.

Ultras are the most extreme-looking hypo-like corns to be discovered so far.

Ruby-red eyes are often apparent in ultras, and some can almost be confused with amelanistic corns. Some hatchlings also have blue or green irises. There is currently some debate concerning whether amel is codominant to ultra, or recessive to it. In other words, it is currently unproven whether there is a difference in the phenotypes of ultras and ultramels. This book treats them as a single phenotype for simplicity's sake.

As adults, ultras and ultramels can become darker. The accumulation of pigment with age can also reduce or remove any ruby glow from the eyes in adults.

It should also be noted that some ultramels may be darker than some ultras, and some ultras/ultramels may resemble standard hypos, so determining genotypes visually may be less than 100% accurate.

The origin of the ultra gene was under some scrutiny and many suspected it originated in gray rat snakes, or “white oaks phase”

gray rat snakes. The hypothesis was tested last year by Russell Keys, who showed that a white oaks gray rat snake was not carrying the ultra gene. More test breedings are planned for 2008 to verify this conclusion.

Since ultra and amel are alleles, and amel is widespread in the gene pool, ultramelts are quickly being produced in combination with the other mutant genes.

## Genetic Combinations with Ultra/Ultramel:

**Ultra/Ultramel + Hypo** – (\$???) This combination is currently unknown.

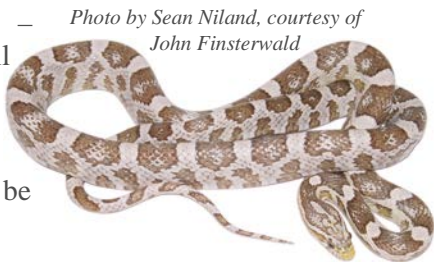
**Ultra/Ultramel + Sunkissed**– (\$???) It appears that this combination will resemble an ultramel in coloration, with the sunkissed pattern. Only a handful of these currently exist.



*Photo by Joe Pierce –  
CornSnakesAlive!*

**Ultra/Ultramel + Lava** – (\$???) This combination is currently unknown.

**Ultra/Ultramel + Anery** – (\$125-150) This morph is still somewhat new. It seems that ultramel anerys and ultramel lavenders might turn out darker than would be expected.



*Photo by Sean Niland, courtesy of  
John Finsterwald*

**Ultra/Ultramel + Charcoal** – (\$???) The first of these might be produced in 2008.



**Ultra/Ultramel+Caramel – (\$70-200)**

**Golddust** corns are similar to butters except the slight amount of melanin present makes them distinguishable from butters.

*Photo by Don Soderberg –  
South Mountain Reptiles*



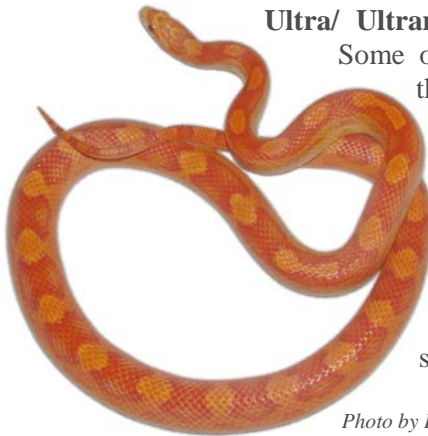
**Ultra/Ultramel + Lavender – (\$???)** These were first hatched in 2007. This morph may turn out to be darker than would have been expected from this combination of genes. The adult coloration is not yet known.

*Photo by John Finsterwald*



*Photo by John Finsterwald*

**Ultra/Ultramel + Diffused – (\$???)** The first of these were produced in 2006. There are now a few breeders making them.



**Ultra/ Ultramel + Motley – (\$100-150)**

Some of these can be so light that they can be mistaken for amelanistic corns. They may even have white flecks on the dorsal pattern. A closer look at the eyes will show that they are not amels. The motley gene, as in other morphs, tends to smooth out the colors.

*Photo by Kat Hall – CornQuest*



**Ultra/Ultramel + Stripe** – (\$???) The first of these were hatched in 2007. They are expected to resemble ultramel motleys in coloration. Future hatchlings will provide the answer to that question.

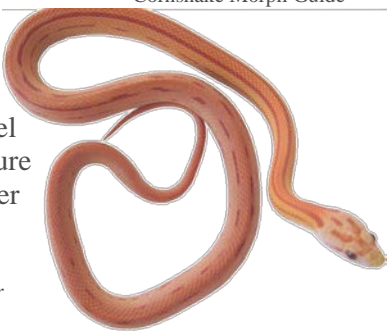


Photo by Stephen Wagner

The Hypo locus:

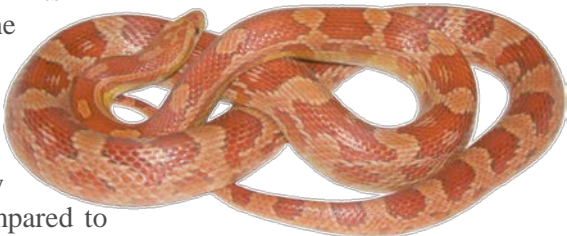
Allele	Name
H <sup>+</sup>	Wild type
h <sup>h</sup>	Hypomelanism

Genotype	Known as:
H <sup>+</sup> · H <sup>+</sup>	Wild type
H <sup>+</sup> · h <sup>h</sup>	Wild type (Het Hypo)
h <sup>h</sup> · h <sup>h</sup>	Hypomelanistic

**Hypo**, aka **Hypomelanistic**, **Hypomel**, **Hypo A**, **Rosy**. (\$25-\$55)

Hypomelanism, as its name implies, has the effect of reducing melanin.

The oranges and reds are generally “cleaner” when compared to normal corns, the black borders are often thinner, and the belly checkers often are bronzed. But in some cases, the darkest hypos can be darker than light-colored normals.



Hypomelanism is recessive to its wild-type allele, so only homozygous specimens express the hypo phenotype. There is some debate about this gene being not entirely recessive, and it seems that in certain lines the hets might be somewhat lighter than their non-het siblings.

Although this trait is generally considered a “color” it also seems to affect the pattern, by reducing the migration of the melanin-producing areas. The result of this “pattern change” can be thinner border areas and a white stripe down the belly where the checkers do not fully meet.

Note that the thinner borders and bronzed belly checkers are not absolute indicators of hypomelanism and visual identification of adults can be tricky. If a cornsnake has lighter/cleaner colors, thinner than normal borders, or bronzed belly checks, it is not necessarily a hypo.

The best identification is made by comparing hatchlings, where hypos are usually quite obvious compared to non-hypo siblings. Hatchlings have a lighter brown/red tone to the saddles compared to normals. Some non-hypo corns will grow up to be extremely light, making identification of adults tricky. In cases where a hypo-like adult or subadult comes from unknown sources, breeding trials are the only way to determine the genotype.

Some of the examples include both male and female specimens, to demonstrate the visible differences typically found between the sexes.

## **Selectively-bred variations of Hypos:**

**Crimson, Hypo Miami** (\$40-100, varies greatly with quality)

These are what you would expect from adding hypomelanism to a typical Miami phase cornsnake. The look, especially the ground color, can vary depending on the stock a given breeder started with, and the direction they took their project. Some are clean gray, and others have a clean tan ground color. Hypos cannot be het for crimson or “Miami.”

## Genetic combinations with Hypo:

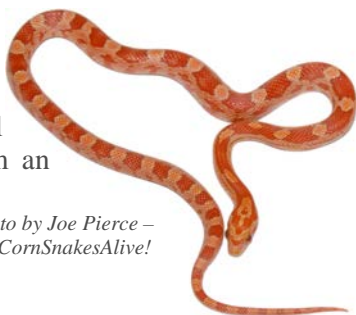
**Hypo + Sunkissed** – (\$???) This combination creates two additive “hypo” effects, making these snakes even lighter than either type by itself. The sunkissed pattern is visible, too.

*Photo by Deb Morgan*



**Hypo + Lava** – (\$???) The combination of these two genes is still very new. It remains to be seen how these two genes will interact. This specimen came from an Okeetee-like line of hypos.

*Photo by Joe Pierce –  
CornSnakesAlive!*



**Hypo + Anery** – (\$25-50)

Ghost corns are one of the most common double genetic combinations. They are a light version of anerythrism. Colors often turn to light browns, tans, and some ghosts develop “peach” and other pastel colors. As seen in these juveniles, males are lighter and more “colorful” than females.

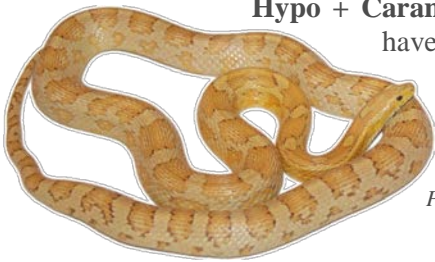


**Hypo + Charcoal** – (\$45-90)

**Phantom** corns seem to be more of a niche morph than ghosts. They tend to be slightly lighter in color than ghost corns, but less colorful.

Some will develop “purple” or “lavender” type tones, similar to what is seen in younger charcoal corns.





**Hypo + Caramel** – (\$50-60) **Amber** corns have light brown saddles on a tan to yellow ground color. They are now being bred with the stripe and motley patterns.

*Photo by Russell Keys*

**Hypo + Lavender** – (\$100-125) Young males expressing this combination are one of the most bizarre looking corn morphs to be found.



The overall colors are lightened compared to lavenders, and the pink/orange wash that develops in young lavenders can be even more apparent.

Adult males are very light, and adult females can resemble regular lavenders.



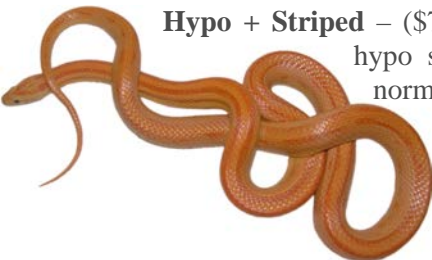
**Hypo + Diffused** – (\$100-150)

Most examples are out of bloodred lines and tend toward dark orange saddles on an orange ground color.

*Photo by Russell Keys*

**Hypo + Motley** – (\$35-\$70) The motley trait already has its own

“hypo-like” effect. Hypo adds to this to create hypo motleys even lighter than normal motleys. This specimen is from the Strawberry lines.



**Hypo + Striped** – (\$75-\$100) Like hypo motleys, hypo stripes are even lighter than normal motleys or stripes.

*Photo by Caroline Piquette –  
Breeding Colors*

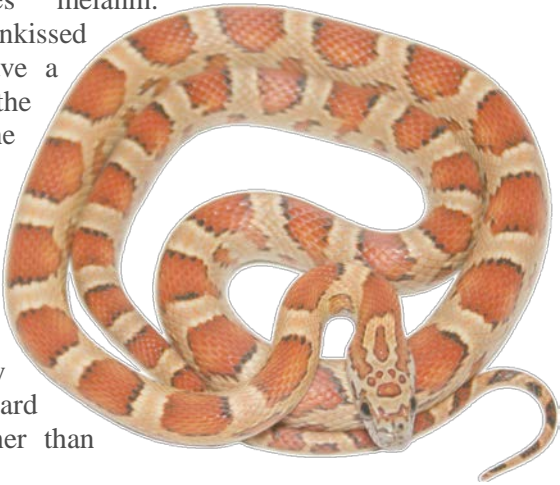
The Sunkissed locus:

Allele	Name
S <sup>+</sup>	Wild type
s <sup>s</sup>	Sunkissed

Genotype	Known as:
S <sup>+</sup> • S <sup>+</sup>	Wild type
S <sup>+</sup> • s <sup>s</sup>	Wild type (Het Sunkissed)
s <sup>s</sup> • s <sup>s</sup>	Sunkissed

**Sunkissed, Sunkissed Okeetee, “Hypo Okeetee” (\$50-\$85)**

At first glance, sunkissed corns might resemble hypos. Like hypo, this trait reduces melanin. However, the sunkissed gene appears to have a significant effect on the pattern as well as the color. The simplest way to describe it is to say that it increases the amount of ground area, and erodes the saddles so that they tend more toward convex shapes, rather than concave shapes.



The example above is *not* typical of sunkissed corns commonly found on the market at this time. Since the gene originated in Okeetees, the vast majority of sunkissed corns are in fact sunkissed Okeetees or have a very strong Okeetee influence. More and more non-Okeetee sunkissed corns are being produced as byproducts of outcrossing them to other genetic lines, and the distinction between sunkissed and sunkissed Okeetee will become more important, so it is helpful to understand from the start that the sunkissed gene does not make a snake look like an Okeetee.

In some cases where the pattern is not as strongly affected, sunkissed might *mimic* hypo. In these cases, a visual ID of an

otherwise unknown snake might not be 100% accurate. It is wise to ensure you know the genotypes of the parents, or perform breeding trials in order to make a positive ID.

A hypothesis, proposed and being investigated through breeding trials by Connie Hurley, is that the pattern and color effects of sunkissed are separable. If this turns out to be true, sunkissed could be a very good mimic of hypo. It will likely be a few more years before such a determination can be made with any certainty.

*Normal*



Another distinctive characteristic of many sunkissed corns is the saddle-colored band going across the nose, which is thinned. Also common are the small dots on the nose. Note that many striped and other corns also have the thinned eye band. This is simply a

*Sunkissed*



result of increased ground area and reduced saddle area (via mutant genes or selective breeding) and does not mean that all snakes with thinned eye bands are sunkisseds.

The last characteristic that seems to be caused by the sunkissed gene is very strong belly checkering. In many examples the belly is more aptly described as white checkers on a black background. Sunkissed motleys have been found to possess belly checkers, and the same might hold true for sunkissed stripes.

Currently, some corns labeled as “hypo Okeetee” are based on the standard hypo gene, and others on the sunkissed gene. Be sure you know which gene you are getting if you plan to breed to other hypos.

## Selectively-bred variations of Sunkissed:

### Sunkissed Okeetee (\$50-85)



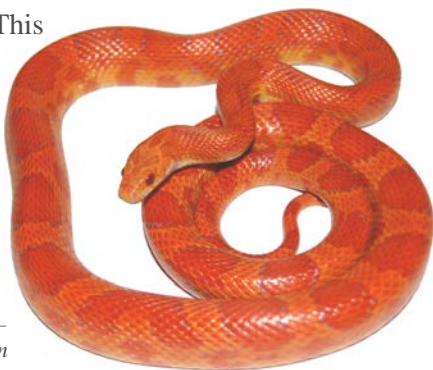
Since this gene originated within Kathy Love's Okeetee lines, the first sunkissed corns were Okeetees. The majority of them on the market today are more okeetee-like than not.



## Genetic combinations with Sunkissed:

**Sunkissed + Lava** – (\$???) This combination is still quite new but appears to be what one would expect from the mixing of these two genes. Having Okeetee influence on both sides should help to create some very bright specimens of this morph.

*Photo by Robin Teeninga –  
www.rrsnakes.com*



**Sunkissed + Anery** – (\$???) Several hets have reached adulthood, so these are expected to appear soon, possibly in 2008.

**Sunkissed + Charcoal** – (\$???)

A handful of these currently exist. It appears they will have phantom-like colors with the sunkissed pattern.

*Photo by Jeff Mohr -  
MohrSnakes*



**Sunkissed + Caramel** – (\$???)

The only known specimen so far is much higher contrast than most ambers. This may be a result of the Okeetee ancestry.



**Sunkissed + Lavender** – (\$???)

Only a few of these exist so far. It appears these will be very similarly colored to hypo lavenders.



**Sunkissed + Diffused** – (\$???) The interaction of these two genes could take a number of different forms. Its first appearance, possibly in 2008, is highly anticipated.

**Sunkissed + Motley** – (\$???) It is expected that sunkissed motleys will not express the connection between saddles. Instead the rounded saddles may curve somewhat toward each other, but not completely connect. Belly checkers also



Photo by Jay & PJ Coombs - PJC Reptiles

can appear on some sunkissed motleys, although they don't tend to be as numerous as a typical snake. The back cover of this edition shows the ventral pattern of a sunkissed motley caramel.

**Sunkissed + Striped** – (\$???) Given the increased areas of ground color in both morphs, it is suspected that these two traits may be additive and reduce or remove what little saddle color exists on the snake.

The Lava locus:

Allele	Name
$V^+$	Wild type
$v^v$	Lava

Genotype	Known as:
$V^+ \cdot V^+$	Wild type
$V^+ \cdot v^v$	Wild type (Het Lava)
$v^v \cdot v^v$	Lava

**Lava** (formerly *Transparent Hypo*, *Trans*) (\$65-\$150)



This is the third hypo-like trait to be discovered and is also a recessive mutant. It acts similarly to the others in that it reduces melanin and creates a brighter overall appearance.



Hatchlings can appear almost amelanistic. The eyes have a ruby glow as a result of the extremely reduced melanin. Some specimens exhibit splotches of black, as if the gene's effect was not complete on that scale. This is often called a "paradox lava." Also, some specimens can have an interesting look about certain areas of scales, almost as if they have been coated in wax. Two main bloodlines exist. One is a "landrace" lava line which traces its roots back to wild corns. The other lavas have been crossed into various domesticated lines to produce genetic combinations.

It is hypothesized that the lava trait might also enhance the oranges in the ground color. The lava gene has now been outcrossed into a good number of unrelated lines in order to create hets for various genetic combinations, and future comparison of F2 and more outcrossed lavas to their siblings should shed light on the hypothesis. As it stands the vast majority of lava corns today exhibit increased orange coloration.

## Genetic combinations with Lava:

**Lava + Anery** – (\$175-225) A

more extreme ghost-like morph is the *Ice* corn. Many subtle colors, such as a blue tint on the head, as well as pink undertones on the body, have been seen in this morph. Males can be very colorful and tend to be much lighter. Pictured are a male and female together to show the differences typically found between the sexes.



**Lava + Charcoal** – (\$???) No known specimens exist today, but may be hatched in 2008.



*Photo by Dean Arnold*

### **Lava + Caramel – (\$???)**

The first examples of this genetic combo were hatched in 2006 by Joe Pierce and were dubbed **Topaz** corns. This specimen has ruby pupils and green irises.



*Photo by Joe Pierce – CornSnakesAlive!*

### **Lava + Lavender – (\$???)**

The first of these corns were hatched in 2004. It appears that these may be the most extreme version of hypo lavender. The eyes can be just as red/pink as those of amelanistic corns.



### **Lava + Diffused – (\$???)**

This new combination appears to be what one would expect when combining these two morphs.

*Photo by*

*Carol Huddleston – Low Belly Reptiles*



**Lava + Motley – (\$???)** A small number of these have been hatched so far. The next few years should provide us with a good idea of what to expect of this morph. The hatchling depicted here is from a line that involves caramel, so the typical coloration might lean more toward orange than this example.

*Photo by Joe Pierce – CornSnakesAlive!*

**Lava + Striped – (\$???)** Striped Ice (lava anery) corns have been produced, but striped lavas have not been hatched yet.

The Anery locus:

Allele	Name
An <sup>+</sup>	Wild type
an <sup>a</sup>	Anery

Genotype	Known as:
An <sup>+</sup> • An <sup>+</sup>	Wild type
An <sup>+</sup> • an <sup>a</sup>	Wild type (Het Anery)
an <sup>a</sup> • an <sup>a</sup>	Anerythristic

**Anerythristic**, aka **Anery**, **Anery A**, **Black Albino** (\$20 -\$40)  
*Pronounced “An-ur-ee-thris-tik,” or abbreviated to “an-ur-ee.”*

This trait takes away the red and orange coloration, leaving the snake shades of blacks, grays, and browns.

The anery mutant is recessive to its wild-type allele.

This is one of the most common mutants in the cornsnake population and it has been combined with nearly every other mutant.



The typical yellows on the chin/neck/belly are unaffected by anery. Although all corns have a pinkish “blush” tone on their cheeks, it tends to be much more noticeable on anerys than most other morphs.

A few red freckles may appear on the body of the snake. These usually appear after a shed, and can stay for the rest of the snake’s life. Hatchlings are an attractive black and silver but the saddle colors often fade to browns, tans, or peach/pastel tones. Sexual dimorphism in anerys (and ghosts) is usually rather obvious, where males are typically more “colorful” and lighter than females.

**Selectively-bred variations involving Anery:**

**Pastel Ghost, Pastel Motley, Pastel Ghost Motley (\$50-65, varies)**

Individual breeders use all of these terms differently. Generally it refers to softened pinkish saddles and/or ground colors on a number of different anery-based cornsnake morphs. The males tend to be more colorful and “more pastel” than the females.



*Photo by Russell Keys*

Some anerythristic motleys will get as light as ghosts and are sometimes referred to as “ghost motley” even though no hypomelanism is present. Some breeders will only use the term “ghost” when hypomelanism is present, and some will use the term based only on how light-looking the colors are.

It is a good idea to find out from the breeder which genetic combination is being expressed, especially whether or not hypo is being used in each combination. Until/unless a genetic influence causing the “pastel” look has been isolated and proven out, ghost corns cannot be het for “pastel.”

**Coral Snow (\$???)** – These were originally assumed to be hypo snows, and currently the term “coral snow” is used for either situation. These particular snows



are believed to involve selective breeding (or a currently unidentified gene) to bring out the intense coral colors. They can be colorful enough to be mistaken for amelanistics in

some photos. Be sure you know which “type” of coral snow you are buying.

**Pink and Green Snow, Green Blotched Snow (\$???)**

Some snows and amelanistics can have bright yellow saddles, and show a greenish cast in the areas where the black borders exist on normal cornsnakes. Some breeders have enhanced this trait through selective breeding. These are dubbed “pink and green” snows. They are sometimes referred to as “bubblegum” snows, although a line of ratsnake hybrids is also called “bubblegum.”

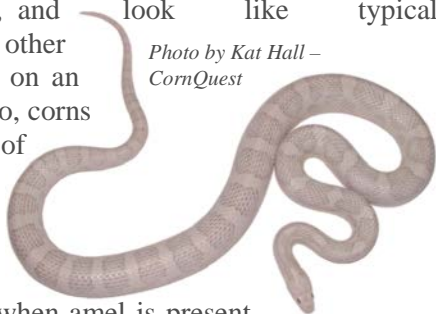
## Genetic combinations with Anery:

**Anery + Charcoal** – (\$???) Individuals of this genotype must certainly exist by now, but have not been formally identified. It is still unknown whether they will appear like normal anerys, normal charcoals, or an intermediate of the two.

**Anery + Caramel** – (\$60-\$80) It appears that caramel is unable to exert its influence when anery is showing. That is, caramel is masked by anery. As a result, these individuals are expected to look like any other anery.

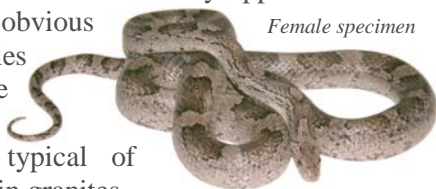
**Anery + Lavender** – (\$80-100) Some cornsnakes are known homozygous for both traits, and look like typical lavenders. Meanwhile other known anery lavenders take on an intermediate appearance. Also, corns of the triple combination of anery, lavender, and amel appear to look like typical snows. One theory is that lavender can mask the expression of anery, except when amel is present. There is still plenty of mystery remaining in this morph.

*Photo by Kat Hall –  
CornQuest*



**Anery + Diffused** – (\$85-125) Some male **granite** corns can have odd “pink” tones to their sides. This tendency appears to run in families, and it can be obvious enough that males and females in these clutches can be visually identified based on their colors. Dimorphism typical of other anerys is also apparent in granites.

*Female specimen*



**Anery + Motley** – (\$50-65) Many of these are similar in coloration to ghost corns. As with almost all motley corns, the smoothing of colors and checkerless belly are present.





**Anery + Striped** – (\$50-65) These are similar in color schemes to anery motleys. Some examples of this morph can become almost patternless. A few breeders are making an effort to produce totally “patternless” cornsnakes through this and a few other morphs.

*Photo by Kat Hall – CornQuest*

The Charcoal locus:

Allele	Name
Ch <sup>+</sup>	Wild type
ch <sup>c</sup>	Charcoal

Genotype	Known as:
Ch <sup>+</sup> · Ch <sup>+</sup>	Wild type
Ch <sup>+</sup> · ch <sup>c</sup>	Wild type (Het Charcoal)
ch <sup>c</sup> · ch <sup>c</sup>	Charcoal

**Charcoal, aka Anery B** (\$30-\$40)



This was the second anery-like trait to be discovered, and in many ways it mimics anery. As in anerys, the pinkish “blush” on the cheeks stands out.

As a broad generalization, charcoals have a darker ground color and are lower in contrast than anerys. However, there is so much variation in both anery and charcoal that they often look similar to each other. Hatchlings generally have a purplish cast to them, and tend to look slightly different than anery hatchlings, enough that experienced breeders can pick them out of a crowd. Adults sometimes cannot be reliably identified by looks alone, so be sure you know which type you are getting if you plan to breed them.



A common myth is that charcoals do not develop yellow on the chin/neck and that anerys do. Originally this was true, but this myth has been dispelled as charcoals with yellow on them, and anerys without yellow, have appeared. The appearance or absence of yellow is **not** a reliable way of determining the difference, although a trained eye can often spot differences in the *quality* of the accumulated yellow.

## Genetic combinations with Charcoal:

**Charcoal + Caramel** – (\$???) Currently unknown.

**Charcoal + Lavender** – (\$???) Currently unknown/unidentified.

**Charcoal + Diffused** – (\$80-\$125)

**Pewter** corns range from very dark to very light. This is a niche morph: people tend to either love pewters, or find them uninteresting or unattractive.



**Charcoal + Motley** – (\$???) This morph is still in its infancy. It is unknown if these will resemble anery motleys, if they will take on colors similar to phantom corns, or if they will have a new look of their own.

*Photo by Jeff Mohr – MohrSnakes*



**Charcoal + Striped** – (\$???) This combination was first produced in 2004 by South Mountain Reptiles. It is still uncommon at this point.

The Caramel locus:

Allele	Name
$Ca^+$	Wild type
$ca^c$	Caramel

Genotype	Known as:
$Ca^+ \cdot Ca^+$	Wild type
$Ca^+ \cdot ca^c$	Wild type, Het Caramel (varies)
$ca^c \cdot ca^c$	Caramel

### Caramel (\$20-\$40)

*Photo by Caroline Piquette – Breeding Colors*



Caramel appears to remove the red pigmentation. Many caramels have a yellow wash over the entire body. The result is a corn in subtle shades of yellows and browns.

This is not the same type of thick, dark yellow that accumulates on the neck/chin of cornsnakes. In fact, the accumulated yellows can easily be seen on caramels. Some have little or no extra yellow wash, and it is unclear whether this is simply the result of selective breeding, an influence of the caramel trait, or the result of a secondary trait.

Another way to view this trait is to see it as one that turns the red/orange pigments *into* yellow. The removal of reds acts like a recessive trait and is only expressed in homozygous specimens. Meanwhile the augmented yellow often appears in hets, usually beginning several sheds after hatching, suggesting that this part of the phenotype acts like a codominant trait. The amount of yellow tends to vary in line with what would otherwise be the amount of orange on the snake's ground color. On "Miami phase" specimens, the hets can turn a particular shade of yellowish tan.

Saddles on caramel hatchlings are brown. Some hatchlings can look very similar to anerythristic hatchlings before the yellows appear.



## Genetic combinations with Caramel:

**Caramel + Lavender** – (\$???) This combination is still new and it is unknown what the typical look will be.

*Photo by Kat Hall - CornQuest*



**Caramel + Diffused** – (\$???)

This combination is starting to become more common, and might become readily available on the market soon.

*Photo by Walter Smith*



**Caramel + Motley** – (\$50-65) As with other motley-based and stripe-based combinations, many of these tend to take on a “hypo” appearance and have lighter colors than standard caramels. Pictured is a hatchling, with only the first hint of any yellow in the ground color.



**Caramel + Striped** – (\$150-175) As with other motley-based and stripe-based combinations, many of these tend to take on a “hypo” appearance and have lighter colors than regular caramels.

*Photo by Kat Hall –  
CornQuest*



The Lavender locus:

Allele	Name
$L^+$	Wild type
$l^1$	Lavender

Genotype	Known as:
$L^+ \cdot L^+$	Wild type
$L^+ \cdot l^1$	Wild type (Het Lavender)
$l^1 \cdot l^1$	Lavender

## Lavender (formerly known as “Mocha.”) (\$50-\$100)

The lavender gene is considered recessive to its wild-type allele. As adults, lavenders end up with a pattern made of dark and light shades of an odd gray color. It is impossible to describe in words.

Lavenders *must* be seen in person to be fully appreciated.



Hatchlings can appear somewhat similar to anery hatchlings but have a lighter “brown” saddle color. It seems

there are two general classes of lavenders, those that are “mocha” colored and those that are more of a neutral gray. These differences may or may not be more commonly sex-linked with the males being the lighter specimens and the females being the “mocha” variety.

As juveniles, many lavenders will have an odd wash of ground color. This wash can be orangish, pinkish or purplish, and as they become adults it fades. Many lavenders will have ruby-colored eyes. But this is not a sure-fire indicator that an individual is a lavender, since there are several other morphs that also have ruby eyes.

Many lavenders, and normal corns from lavender lines, also have unusual patterns resembling *aztec* and *zigzag*. It is unclear whether or not this is directly related to, or linked to, the lavender trait. Normally patterned lavenders can also produce offspring with these odd patterns.

Genetic combinations with Lavender:

**Lavender + Diffused (\$???)** – The *plasma* corn is the subject of many projects and is expected in good numbers over the next few years. Overall darkness is highly variable between individuals. Some appear to resemble light-silvery pewters and others resemble dark gray pewters, but with less of the browns.



Photo by Walter Smith

**Lavender + Motley (\$120-200)** – Lavender motleys have become more popular over the last several years and are becoming available and affordable. As with other lavenders, colors are highly variable between individuals.



**Lavender + Striped (\$???)** – These are still hot items, since only a few of them exist. Several breeders are now working with them and they will likely become more common in the coming years.



Photo by Joe Pierce –  
CornSnakesAlive!

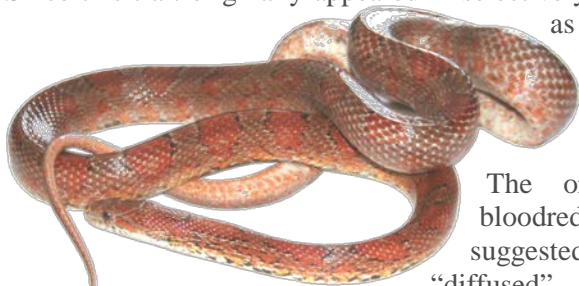
The Diffusion locus:

Allele	Name
D <sup>+</sup>	Wild type
D <sup>D</sup>	Diffusion ( <i>also called “Bloodred”</i> )

Genotype	Known as:
D <sup>+</sup> • D <sup>+</sup>	Wild type
D <sup>+</sup> • D <sup>D</sup>	Intermediate ( <i>ranges from normal to almost fully diffused pattern</i> )
D <sup>D</sup> • D <sup>D</sup>	Diffused pattern ( <i>also called “Bloodred”</i> )

## Diffused (Also called *Bloodred* or *Blood*) (\$60-\$90)

Since this trait originally appeared in selectively bred corns known as bloodreds, the name “bloodred” is still often used for the gene.



The originators of the bloodred corns have suggested using the name “diffused” for this gene/trait/pattern in order to avoid confusing the genetic pattern mutant with the selectively bred color morph. The Cornsnake Morph Guide uses that convention in order to separate discussions of the diffusion pattern trait from the selectively bred bloodred morph.



Three main effects on the pattern are observed. The belly is wiped clear of checkers. However, some black specks or freckles can appear. The head pattern is often stretched, and the top of the head can have a “skull” type pattern on it.

The pattern on the side of the body can be practically normal, or almost completely blurred out. (The more diffused/blurred side patterns are usually more desirable.) The diffusion pattern (like motley) often creates a mild lightening effect similar to (but not related to) hypomelanism.

Hatchlings may start out with a lot of gray on the head and ground areas, which then develops into the reds, oranges, or browns they will have as adults. In this morph, the ground color can become darker than the saddle color.



Many breeders have also observed that in full clutches of known hets, male hets will show much more of the traits than the female hets. The differences may be obvious enough to identify males and females by looking at their patterns. It's possible that this difference is either related to or a direct result of the *masque* gene.

Diffusion is a Mendelian pattern trait, but its expression can vary between individuals. It tends to act mostly like a recessive gene, but

some hets may show hints or significant amounts of the diffused pattern. The amount of expression seems to be fairly consistent within each bloodline, which suggests the diffusion gene is *not* the cause. Even the most extreme-looking hets generally do not express the “blurred” side pattern, and they will show traces of rectangular markings on the edges of the belly. If you purchase or hatch hets for diffusion, don’t count on them looking severely different from normals.

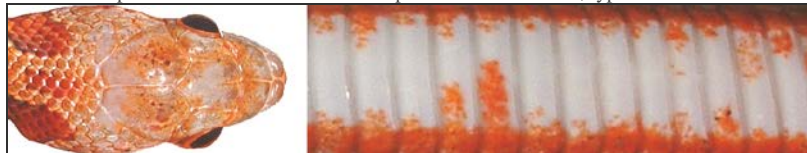
## Selectively-bred variations using Diffusion:

### **Bloodred** (\$60-\$150)

This term is also used by some as the name of the diffusion gene. Selective breeding of individuals expressing the diffusion pattern trait originally created extremely red individuals, which were practically patternless. But some of that quality has been lost in many lines as a result of outcrossing.



“Bald” head pattern and unchecked ventral pattern with red wash, typical of Bloodred corns

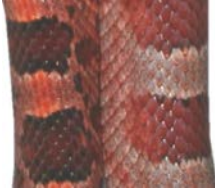


The bloodred morph appears to be made of diffusion plus three additional characteristics: masque, borderlessness, and increased red pigments. The masque and borderless components each appear to be under the control of independent dominant genes, but breeding trials are still underway in an attempt to determine this. The increased red appears to be a selectively bred trait rather than a gene. Since there are strong genetic influences in the best specimens, some F1 offspring from “bloodred x normal” crosses can practically look like bloodreds themselves.

Cornsnakes expressing the simple genetic diffusion pattern trait *and* cornsnakes with the ideal look, and everything between, are called “bloodred” corns by many people. There can be a great deal of

difference in the quality of the pattern and the quality of the coloration, so if you want the selectively bred “bloodred” morph, be sure to find out from the seller what you are getting and/or specify what you want to get.

*Hatchling comparison*



Diffused      Bloodred

Typically the best bloodreds will hatch with a completely patternless gray head or with a gray “skull” type head pattern, a belly with no black checkers or specks on it, side blotches that are very smudged or even invisible, or a side pattern that is a smudge of saddle color, and very little visible “black” anywhere. As they

mature, the ground color on high-quality specimens turns from gray into red. The “color” on the ground is not the typical oranges, or tans/browns, but rather the saddle color coming in where the pattern has been diffused. It can take 5 years for a bloodred to reach its “final” coloration but the first 1-2 years can give a good indication of the changes that will occur.

## Genetic combinations with Diffusion:

**Diffused + Motley** – (\$???) Since it is impossible to make a visual identification with certainty, any snakes coming from a new bloodline will need to be



*Photo by Arjan Coenen – Corns.nl* available.

proven through breeding trials. Several potentials were hatched starting in 2006, and within the next few years, proven specimens should become more widely



*Photo by Joe Pierce – CornSnakesAlive!*

**Diffused + Striped** – (\$???) Like Diffused motleys, these need to be proven through breeding trials. Proven specimens exist and are becoming more common. They are also being produced in combination with anery, amel, and snow.



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*Note: No locus or gene symbols have been assigned to pied-sided yet. Once it has been determined if it resides at the diffusion locus, a symbol can then be assigned.*

### **Pied-sided (\$???)**

The pied-sided trait may be related to the diffusion trait. At this point it has proven to be a single gene. What has not been determined yet is whether the mutant is on a new locus, or if it is an allele on the already known diffusion locus. It will take several years to make such a determination.



*Photo by Don Soderberg –  
South Mountain Reptiles*

The pattern is affected in two main ways. First is, of course, the white patches that can look like the belly pattern has been extended up to the sides. The second effect is a severe “cutoff” of the patterning on the dorsal/lateral line. At this line, the pattern on pied-sided corns simply disappears and is replaced with a strong wash of non-patterned reds. It almost appears as if this trait is a more extreme expression of the diffused pattern, with pattern migration slowed so severely that the belly whites and belly reds end up on the side of the snake. Some specimens have one or two white scales on the nose.

Since it has only been observed in bloodred corns, it is unknown if pied-sided will have any effect in the absence of the diffusion gene.

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## The Motley locus:

Allele	Name
$M^+$	Wild Type
$m^m$	Motley
$m^s$	Stripe

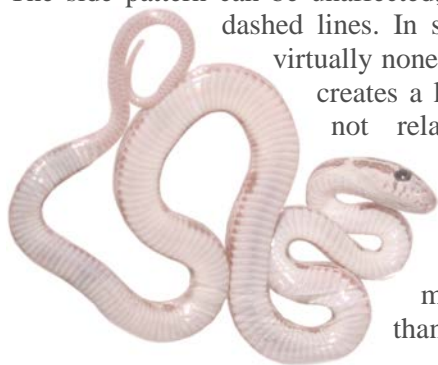
Genotype	Known as:
$M^+ \cdot M^+$	Wild type
$M^+ \cdot m^m$	Wild type (Het Motley)
$M^+ \cdot m^s$	Wild type (Het Stripe)
$m^m \cdot m^m$	Motley
$m^m \cdot m^s$	Motley, het Stripe ( <i>motley pattern</i> )
$m^s \cdot m^s$	Striped ( <i>Four-line stripe</i> )

**Motley** ( $m^m \cdot m^m$ ) (\$30-\$40)

The motley trait clears the belly of checkers. Some motleys will have a few checkers, and many will have black freckles on the belly. A wash of color can also be found in some motley corns. The dorsal pattern often shows a desire to stretch lengthwise. Anywhere from a handful of saddles to all of the saddles will be connected on the outside edges, creating circles along the back. Some normal (non-motley) corns have a “pseudo-motley” pattern on their necks, so the belly is important for proper identification.



The side pattern can be unaffected, or it can be smeared out into dashed lines. In some cases, the side pattern is virtually nonexistent. The motley pattern also creates a lightening effect similar to (but not related to) hypomelanism. For instance, anery motleys are usually lighter than anerys, hypo motleys are generally lighter than hypos, caramel motleys are generally lighter than caramels, etc.



*Checkerless belly of motley and striped corns*

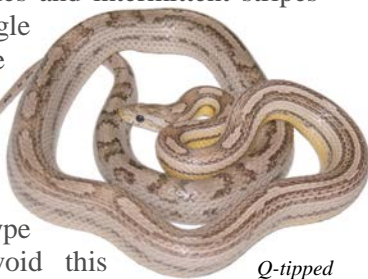


Be aware that the patterns produced by this trait are **highly** variable. This is why it is named *motley*. A wide variety of dorsal patterns can result, even in siblings from the same clutch.

## Selectively-bred variations of Motley:

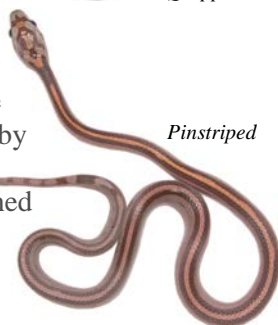
### Pin-Striped and Q-tip Motleys (\$40-\$75)

Some motleys have elongated saddles and intermittent stripes down the centerline, or a single pinstripe down the back. These are often referred to as “motley/striped” or “striped motley” but problems arise with these names because it is then unclear whether the term is describing the snake’s genotype ( $m^s m^m$ ) or its phenotype. To avoid this situation, pin-striped and q-tipped are used to describe these variations.



*Q-tipped*

Pin-striped motleys can usually be distinguished from “true striped” corns by examining the width of the stripes. True striped corns (also known as 4-lined stripes) have a wide stripe of ground color and thin saddle stripes. Pinstriped corns have a central stripe that is thin, or varying



*Pinstriped*

$m^m \cdot m^m$  Pinstriped



$m^s \cdot m^s$  Striped



in width. On pinstriped corns the central stripe is usually broken on the neck. On striped corns the center stripe connects with the head pattern.

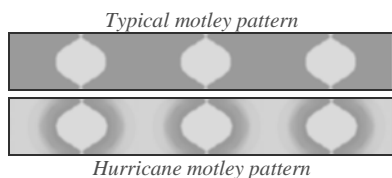
### Miami Motley (\$???)

A few motley and motley/striped corns have been bred to take on the “Miami phase” look. This combines the motley pattern with a smooth silvery gray or light tan ground color. Cornsnakes cannot be het for “Miami.”



*Photo by Carol Huddleston – Low Belly Reptiles*

## Hurricane Motley (varies widely)



areas, and/or fading of the central part of the saddles. In the best specimens the ground and saddles match, leaving only the circles.

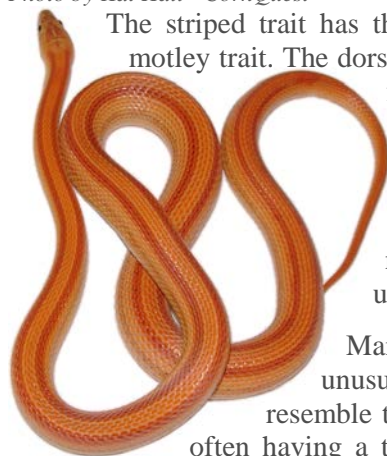


This variation of the motley pattern, also sometimes called *donut* or *bullseye* motley, includes dark outlines around the circles caused by a thickening of the “border” areas, and/or fading of the central part of the saddles. Hurricane motley is found in several color morphs, and are often priced significantly higher than normal motleys of the same color, depending on the quality of the effect.

*Photo by Don Soderberg—  
South Mountain Reptiles*

## Striped ( $m^s \cdot m^s$ ) (\$45-\$60)

*Photo by Kat Hall - CornQuest*



The striped trait has the same effect on the belly as the motley trait. The dorsal and side patterns will be made of four thin stripes running the length of the body. These stripes almost always have breaks in them, especially toward the tail end of the snake. Fully striped corns (with no breaks in the stripes) are uncommon.

Many striped corns will have an unusual head pattern that can somewhat resemble the head patterns of bloodred corns, often having a tendency toward an expanded head blotch, and/or tending toward the ringnecked pattern. As with motley corns, the striped pattern also creates a lightening effect similar to hypomelanism. Striped corns also lack the bordering around the dorsal saddle markings.

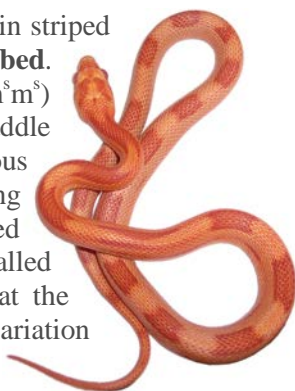
The stripe allele appears to be recessive to the motley allele. This means that a snake of the genotype  $m^m \cdot m^s$  is expected to take on the pattern of a motley corn. It was previously considered codominant with motley and intermediate phenotypes were expected, but that theory has been proven false. The “striped motley” (pin-striped or q-tipped) phenotype is more likely the result of other influences unrelated to the stripe gene. For this reason, the term “motley/striped” is being replaced with pinstriped or q-tipped or other similar terms in order to avoid confusion.

## Selectively-bred variations of Stripe:

### Cubed (\$???)

One of the odd patterns that has appeared in striped and/or motley lines is referred to as **cubed**. Genotypically, these are striped ( $m^s m^s$ ) cornsnakes. As with other stripes, the saddle borders are completely absent. In the various types of cubes, some or all of the striping can be replaced by squares, x-shaped saddles, or ovals. The ovals are also called **sunspots**. Breeding trials have shown that the pattern is most likely a selectively bred variation of the classic striped pattern.

*Photo by Terri Manning –  
The Snake House*



### Vanishing and Patternless Stripes (\$???)

Other variations that have originated in striped lines are known as vanishing stripe and patternless. It appears that vanishing stripe corns are selectively bred striped corns. Patternless also appears to be related to striped corns. It is being investigated by Jeff Mohr as a potential on/off gene, and might be proven out over the next several years.

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## The Cinder locus:

Allele	Name
$Ci^+$	Wild type
$ci^c$	Cinder

Genotype	Known as:
$Ci^+ \cdot Ci^+$	Wild type
$Ci^+ \cdot ci^c$	Wild Type (Het Cinder)
$ci^c \cdot ci^c$	Cinder

**Cinder** (formerly known as Z) (\$???)

Young adult  
female



Cinder hatchlings start out looking like brownish anerys, but an odd red coloration in the saddles can accumulate as they mature. This is a different quality of red compared to other corn morphs. The accumulated “red” can then fade back out in adults. To date, very few adult cinders have been observed.



Belly pattern

It is unclear at this point if an odd pattern effect is also caused by this gene. There are two different general classes of patterns that have been observed. One is a typical “corn” pattern. The other is one of jagged edging to the saddle shapes. Breeding tests over the next several years should shed some light on the nature of the odd pattern, but at this time it appears to be reliably heritable. Cinders are being outcrossed into other morphs to begin the process of making combination morphs. Amel cinders (*see page 58*) have been produced already, and hypo cinders will likely be the next to appear.

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The Dilute locus:

Allele	Name
$Dt^+$	Wild type
$dt^d$	Dilute

Genotype	Known as:
$Dt^+ \cdot Dt^+$	Wild type
$Dt^+ \cdot dt^d$	Wild Type (Het Dilute)
$dt^d \cdot dt^d$	Dilute

## Dilute (\$175)

The dilute gene is the fifth hypo-like gene found in corns. Its effects are more subtle than hypo. The dilute gene also appears to “cool” the overall coloration. The cooling effect may be due to adendritic pigment cells, causing the pigment to be partially hidden behind the iridophore layers. This idea is supported by the observation that all but a small part of the head pattern is invisible in the sheds of these snakes, so that their sheds closely resemble those of a snow or lavender corn.



*Photo by Deb Morgan*

Identifying a dilute specimen is still in its infancy and at this point should be trusted to breeding trials instead of visual identification of specimens from unknown heritage. However, the clear sheds might (*or might not*) eventually prove useful as a method of identification.

Since it was originally proven in anerys, the normal phase had been unknown. Dilute has been outcrossed with several different morphs and was finally produced in normal phase (red-producing) corns in 2007. Other combinations have been produced in small numbers, such as dilute lavender and dilute caramel. New genetic combinations are expected to appear over the next few years.

## Genetic combinations with Dilute:



Photo by Jeff Mohr – Mohrsnakes

**Dilute + Anery**—(\$125-200) Also sometimes called “blue” (especially with “blue motleys”) these snakes start with an appearance between that of anery and ghost in overall lightness. Instead of the warm browns and pastels found on anery/ghost corns, dilutes have more of a steely blue-gray appearance. Known specimens tend to accumulate pastel pinkish ground colors, especially males.

**Dilute + Caramel** – (\$???) One of these was hatched in 2007, but failed to thrive. It was reported that the coloration was just what one would expect from this genetic combination.

The Kastanie locus:

Allele	Name
$K^+$	Wild type
$k^k$	Kastanie

Genotype	Known as:
$K^+ \cdot K^+$	Wild type
$K^+ \cdot k^k$	Wild Type (Het Kastanie)
$k^k \cdot k^k$	Kastanie

## Kastanie (*pronounced kah-stahn-yeh*) (\$???)

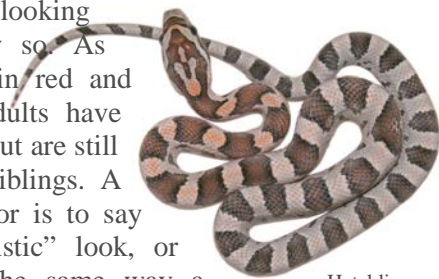


Photo by Michael Gläß

This gene was first recognized and proven as a mendelian recessive trait in Germany. It was later discovered in the North American captive population when a “rosy blood” corn was outcrossed and the kastanie trait appeared in two of the grandchildren.



Kastanie corns hatch out looking either anerythristic or nearly so. As they mature, they slowly gain red and orange pigments. Existing adults have grown toward normal colors, but are still visibly different from their siblings. A simple description of the color is to say they take on a “hypoerythristic” look, or “reduced red pigment,” in the same way a hypomelanistic corn is an intermediate between normal and amelanistic.



Hatchling

## Genetic combinations with Kastanie:

### **Kastanie + Amel – (\$???)**

This combination goes by the trade name of **mandarin** in Germany.

*Photo by Michael Glaß*

**Kastanie + Diffusion – (\$150)** These have been around for years under the trade name **rosy blood**, but it was only recently discovered that they were using the kastanie gene. As a result, they are expected to also be marketed as **kastanie bloods**. This revelation will help speed up the process of making new combinations with kastanie since there are many existing adults to start new breeding projects with.

*Photo by Don Soderberg—  
South Mountain Reptiles*

## Terrazzo (\$???)

*Photo by Tim Jasinski, courtesy of  
Jeff Galewood – JMG Reptile*



Terrazzo is a recessive pattern mutant that originated in upper keys corns. Jeff Galewood proved this as a recessive trait by breeding F1 normal hets to recover F2 terrazzo corns. Genetic testing against the motley locus is planned for 2008, to determine if it is an allele to the motley and stripe mutants in corns. As with the pied-sided mutant, a gene symbol will be assigned once the locus has been determined.

The belly patterns seem to resemble those of motley and striped corns. Jeff Galewood has reported that the saddle colors vary throughout the range of corn saddle colors and the background color has been consistently light or gray tones so far. This coloration could be a result of natural selective breeding in the bloodlines of their ancestors, and like with motley or striped corns, it may be possible to breed terrazzo corns in the orange/red end of



*Photo by Tim Jasinski,  
courtesy of Jeff Galewood – JMG Reptile*

the spectrum by crossing to lines with intense orange ground colors, such as okeetee corns.

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## Other Genes

### Masque:



This appears to be a weakly-expressed mimic of the diffusion gene. Masque gene seems to be more of a minor modifier than a major morph-generating pattern, and it may not even be listed or noticed by many breeders. It might not have enough of an overall effect to warrant



classification in the same category as the other color/pattern genes.

The masque gene has been test-bred against diffusion and has proven to be independent of the diffusion locus. More samples are needed to determine the inheritance for certain, but at this time it appears to be sex-linked, and it usually acts dominant (or semi-dominant) in males and seems to have little effect on females.

The phenotype may be undetectable in females and for the sake of discussion will be treated as if it is only expressed in males. As such, the following description applies almost entirely to the males. The overall scheme is one of expanded ground color and a very mild hypomelanistic effect. The head pattern tends toward a “skull” shape with two oval-shaped “eyes” formed by the saddle color. It can take many forms that tend to resemble ink blots, and what they all tend to have in common is expanded ground color on the head.

The belly has a “white stripe” where the checkers do not reach the center. The sides may show a slight blurring, but at this point it’s possible that this characteristic is part of the existing bloodlines and not a result of the masque gene itself.



To date there are no known homozygous males (and it is assumed females can only be hemizygous) so the phenotype of homozygous males is unknown, and assumed to be either the same as or more extreme than heterozygous males. A breeding intended to produce homozygous males is planned for 2008.

If masque is sex-linked, the inheritance patterns will not be exactly the same as normal mutant genes. Males have two Z sex chromosomes, and females have one Z, one W.

As usual, a homozygous male will pass this gene to all of his offspring and a *heterozygous* male will pass this gene to half of his offspring. However, since females are ZW, they can only be hemizygous, and can carry at most one copy of the gene on their single Z chromosome (and nothing on the W chromosome.) All offspring receiving the Z chromosome are male and all offspring receiving the W chromosome are female, so a hemizygous female will pass this gene to **all** of her sons and **none** of her daughters. From the opposite perspective, males can inherit the masque gene from either parent, but females can only inherit masque from their father.

As a result, outcrossing a normal-looking hemizygous female will produce masque sons and normal-looking (non-carrier) daughters. Meanwhile, outcrossing a heterozygous masque male will produce normal-looking (50% possible carrier) daughters, and a split of normal (non-carrier) and masque sons.

Identification of this gene can be tricky. Since it is a good mimic of many hets for diffusion, a visual ID alone cannot determine which gene (diffusion or masque) is responsible for the phenotype. Also, in clutches where offspring are het for diffusion, the males tend to show more influence from the diffusion gene. As a result, breeding trials can create indeterminate outcomes if the possibility of either gene has not been eliminated from the parents.

It is possible that high-end “bloodred” specimens are actually a combination of both the masque and the diffusion morphs, which could explain why so many hets for diffusion (especially males) show the above phenotype. But it will likely take several years before any such determination could be made.

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## Short-tail mutant:

The phenotype produced by this gene is a shortened tail, which can look "stubby" compared to normal corns. Breeding trials have produced three generations of these snakes and shown that it is either a dominant or semidominant mutant. To date a short-tail X short-tail breeding trial has not been performed to determine the phenotype of homozygotes, but this cross is planned for 2008.

Affected snakes generally have some small, palpable lumps (kinked/fused vertebrae) in the tail which may or may not be visible. The gene appears to have no effect on the health or vigor of the snake. These are not highly angular kinks or corkscrews, some specimens are difficult to detect since the "lumps" can be extremely subtle or nonexistent when viewing or feeling the tail. It should be noted that none of these specimens have shown any signs of spinal deformity in the lumbar or thoracic, vertebrae. This mutant has only been shown to affect the caudal vertebrae, which are in the tail, and appears to be purely cosmetic.

Radiographs (x-rays) were taken of the spines of normal and short-tail corns. The differences are shown below.



Several genes producing similar phenotypes are known in mammals including dogs, cats, and mice. In some cases these are widespread and considered to be "normal" for a particular breed.

Since this gene is not recessive, anyone wishing to remove it from their colony or avoid bringing it into their colony can simply not purchase, or not breed, any snakes showing this phenotype. It should be noted that, like all dominant and codominant genes, unaffected snakes that are siblings to short-tails, or offspring of short-tails, are **not** carrying this gene.

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**Stargazer mutant:**

Stargazing in corns is a neurologic condition that seems to be inheritable as a simple-recessive gene. It results in a neurologic condition which affects the snake's ability to move correctly. At rest they appear normal. But when stimulated to move, they show uncoordinated, jerky movements with a loss of fine motor control. The more focused they are on a goal the more uncoordinated they become. Dr. Connie Hurley has noted that this seems to be very similar to cerebellar hypoplasia in mammals (lack of development of the cerebellum of the brain), which causes loss of fine motor control, uncoordinated gaits, and intention tremors (which worsens the more they concentrate on something.)

While the snake is crawling, its head may weave back and forth or even flip back, giving the characteristic "star gazing" appearance for which they are named. Some may even crawl upside down or backwards. Mentally, they appear to be normal, and eat, drink, eliminate, and seek hides just like a normal corn snake. They also respond normally to stimuli such as getting excited when they smell food, or striking and fleeing when feeling threatened. They don't appear distressed or in any pain from the condition.

Since this gene is not dominant or codominant, it may be difficult to remove from a colony. Breeding trials using known carriers would be required to verify any snake as a non-carrier. Avoiding inbreeding may keep the gene from being paired up and thus expressed within the direct progeny, but this is only a short-term solution. Unfortunately this practice will result in the gene being unknowingly propagated (in the form of "50% possible hets") throughout the entire corn population until many unrelated snakes become carriers. In the future, even random outcrossings between different morphs will be able to produce stargazers, the way amelanism does today. The only way to avoid propagating this (or any recessive) gene is through proving future breeders as non-carriers before their offspring are allowed to enter the gene pool. In order to do this, known carriers of the gene (also called "*S-factored*") are needed to test suspect animals and eliminate them from the breeding program.

## Additional Morphs

Counting only the possible genetic combinations, and ignoring all the selectively bred variations, there are over 55,000 possible morphs. Following are some of the triple combinations, quad combinations, and other variations that don't quite fit the simpler classifications. Red-removal (anery, caramel, charcoal, lavender) plus black reduction (ultramel, hypo, lava, sunkissed) plus pattern alteration (motley, striped, diffused) is a very popular formula for creating new genetic combos. The cinders, kastanies, dilutes, and terrazzos offer yet another set of branches.

+Ultra/amel

+Caramel

+Motley

*Photo by Bill & Kathy Love –  
Cornutopia.com*



+Hypomelanism

+Caramel

+Motley

*Photo by Jeff Mohr – MohrSnakes*

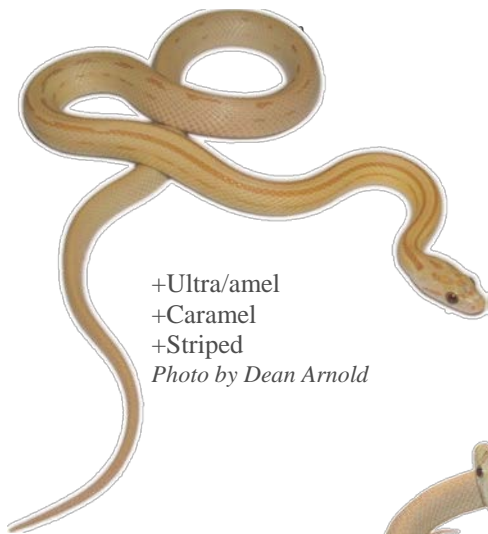
+Sunkissed

+Caramel

+Motley

*Photo by Charles Pritzel –  
CCCorn*





+Ultra/amel

+Caramel

+Striped

*Photo by Dean Arnold*



+Hypomelanism

+Caramel

+Striped

*Photo by Caroline*

*Piquette – Breeding Colors*



+Amelanism

+Caramel

+Striped

*Photo by Caroline*

*Piquette – Breeding Colors*



+Amelanism

+Caramel

+Motley

*Photo by Russell Keys*



+Amelanism

+Caramel

+Diffusion

*Photo by Rob Stevens –  
Bayou Reptiles*



+Hypomelanism

+Caramel

+Diffusion

*Photo by Joe Pierce –  
CornSnakes Alive!*



+Hypomelanism

+Charcoal

+Diffusion

*Photo by Charles Pritzel –  
CCCCorns*



+Hypomelanism

+Charcoal

+Motley

+Q-tipped variation  
of motley pattern

*Photo by Jeff Mohr –  
MohrSnakes*

- +Ultra/amel
- +Anerythrism
- +Motley

*Photo by Don Soderberg –  
South Mountain Reptiles*



- +Dilute
- +Anerythrism
- +Motley
- +Pinstriped variation  
of motley pattern

*Photo by Jeff Mohr –  
MohrSnakes*

- +Lava
- +Anerythrism
- +Motley
- +Pinstriped variation  
of motley pattern

*Photo by Jeff Mohr –  
MohrSnakes*



- +Lava
- +Anerythrism
- +Striped

*Photo by Joe Pierce –  
CornSnakes Alive!*



- +Hypomelanism
- +Anerythrism
- +Diffusion
- +Striped

*Photo by Joe Pierce –  
CornSnakes Alive!*



- +Amelanism
- +Anerythrism
- +Diffusion
- +Striped

*Photo by Joe Pierce –  
CornSnakes Alive!*

- +Amelanism
- +Diffusion
- +Striped

*Photo By Caroline Piquette –  
Breeding Colors*



- +Hypomelanism
- +Anerythrism
- +Striped

*Photo by Russell Keys*



+Amelanism  
+Lavender  
+Motley  
*Photo by Charles Pritzel – CCCorns*

+Hypomelanism  
+Lavender  
+Motley  
*Photo by Carol Huddleston – LowBelly Reptiles*



+Hypomelanism  
+Lavender  
+Diffusion  
*Photo by Carol Huddleston – LowBelly Reptiles*

+Amelanism  
+Sunkissed  
+Motley  
+Caramel (suspected)  
*Photo by Charles Pritzel – CCCorns*



## Pattern Formation

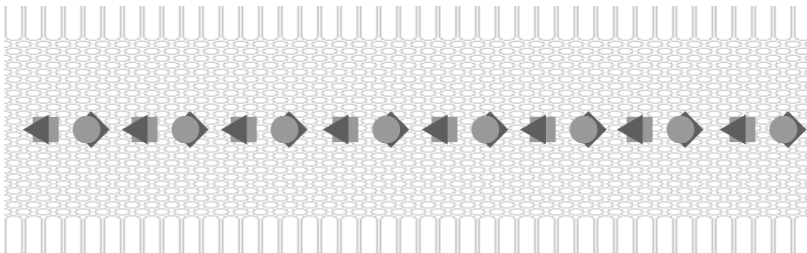
The following chapter describes a model for pattern formation. This model is only hypothetical and may or may not be an exact description of the true process. It is based on the way patterns are formed in other vertebrates (fish, lizards, birds, and mammals) and should serve as a good tool to visualize and understand how cornsnake patterns come to be.

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### *The “Neural Crest Migration” Model:*

In early development of embryos, one group of cells, known as the *neural crest*, differentiates itself. This group of cells eventually becomes the nervous system, brain, spinal cord, eyes, and the pigment cells on the skin. Since the pigment cells are closely related to the cells forming the nervous system, this could explain why many defects in skin pigment (in mice, dogs, cats, and horses, and humans, for example) are often accompanied by neurological defects such as blindness, deafness, megacolon, "lethal whites," etc.

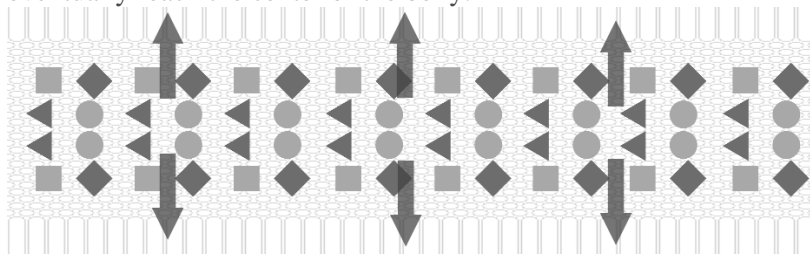
The pattern in cornsnakes appears to be made of four different types of cells, one produces the saddle color, one produces the border color, one produces the ground color, and the last type only produces iridophores, which creates the white areas. Areas where no iridophores and no pigments are produced end up being a pinkish flesh color. When these cells divide, the resulting daughter cells have the same "destiny" as the original cell and will produce the same pigment.



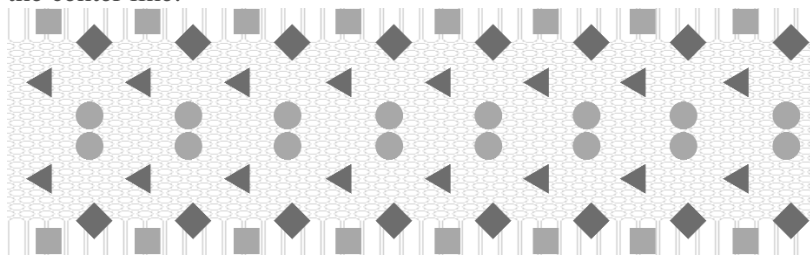
*Illustration 1 - cells moving from head to tail along the spine, with subgroups beginning to form.*

The cells that create the pattern start out approximately where the brain is, and then migrate in two groups (one on the left side and one on the right side) down the center of the back, moving toward the tail and the nose. While migrating, they divide into subgroups and multiply.

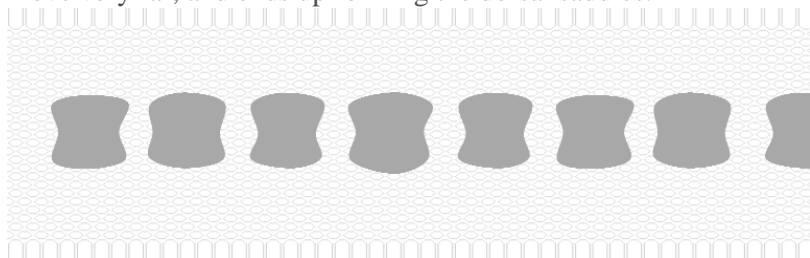
These cells then migrate "downward" around the sides and eventually reach the center of the belly.



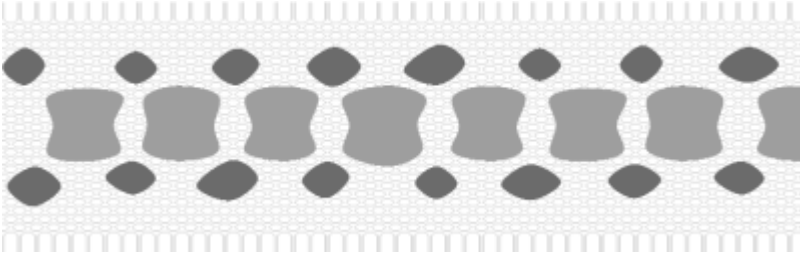
At this point in development, the two sides of the belly are not "connected" to each other, thus the migration does not go beyond the center line.



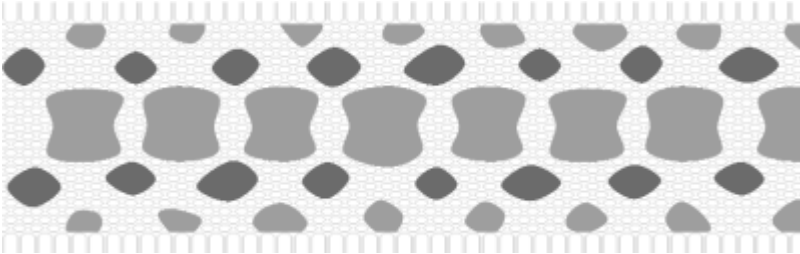
Once these groups of cells have reached their destination, they begin expanding to create their areas of color. For the first three groups, this area is filled with red pigment cells. The first group does not move very far, and ends up forming the dorsal saddles.



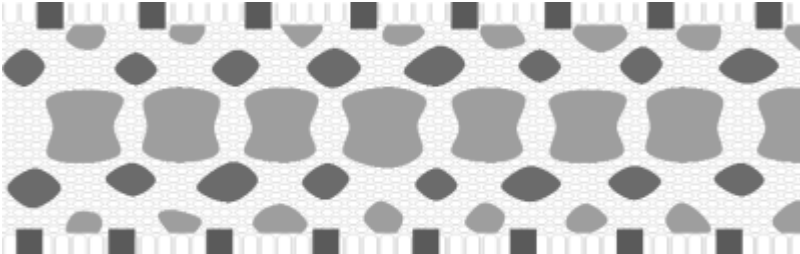
The next group moves approximately halfway down the sides and forms the main side blotches.



The third group moves to the edges of the belly scales and forms the lower side blotches.



The last group migrates all the way to the belly and creates the dark checkers on the scutes.



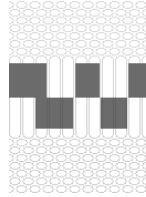
The cells that control ground color spread out into the remaining areas, and tend to be most concentrated between the saddles.

*If anything slows the process of this downward migration, the first thing to be noticed will be an absence of pattern at the center of the belly. This is also seen as a "white stripe" on the center of the belly. Several cornsnake mutants affect the belly pattern this way.*



The borders are created by a group of cells surrounding the original group. This also grows as the saddles expand.

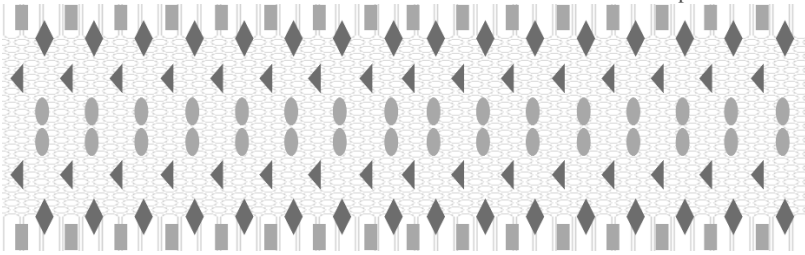
The fourth group, which forms the belly checkers, does not appear to start with red, but rather expands to fill the scales with black, from the outside "flat edge" to the centerline, and from the front to back edges of the scales.



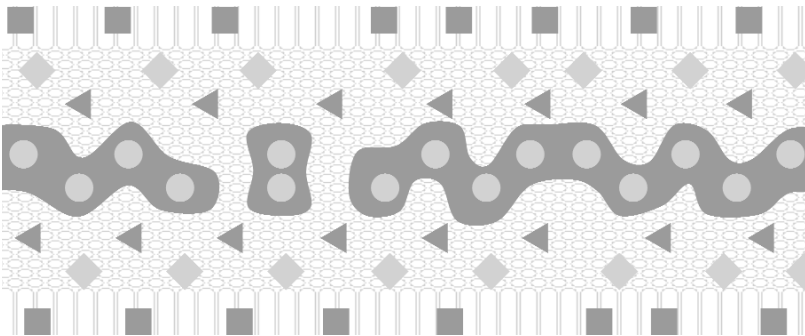
A large number of genes are responsible for controlling the destiny of these pigment cells. As such, a large number of different mutations can modify the way these cells migrate, whether they live or die, the direction and/or pace of their migration, and the direction and/or pace of their expansion. Following are some examples of patterns and how they might be viewed using the migration model.

The well-known standard hypomelanism, which has long been considered a "color morph," may fit this model as a pattern gene. It appears that the border areas on snakes homozygous for hypo are often significantly thinned, even when melanin is not being produced. This is especially apparent when comparing the borders on ultramels versus hypos. (Ultramels appear to have normal-width border areas.) It is possible that hypomelanism actually slows or otherwise hampers the migration or division rate of "border cells" and "checker cells" thus causing the pattern to have smaller border areas. This could also cause the belly checkers on hypos to be faded and/or not completely reach the center of the belly.

A new mutation, known as cinder, appears to affect the number of saddles that appear along the length of a snake's body, increasing saddle counts by approximately 25%. This could be caused as the groups initially subdivide, by increasing the frequency of these divisions. Similar mutations might be found which do the opposite, and lower the snake's saddle count.



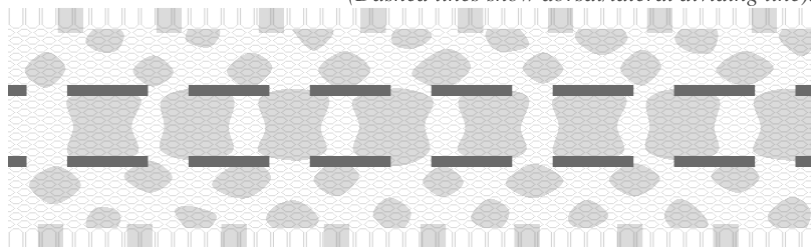
Normally, the cells on one side of the centerline match the activity of the cells on the other side, resulting in symmetry. The zigzag pattern could result when a division on one side is *not* matched on the other side, and those groups of saddles become offset until another unmatched division occurs. These would occur randomly, as opposed to a specific gene controlling the exact point at which an offset occurs. Since half of these unmatched divisions *create* the zigzag pattern, and the other half *remove* the zigzagging, a large number of these "offsets" could cause patterns that are not as zigzagged as a snake with only one or a few offsets. This could account for the unpredictability of this pattern's appearance.



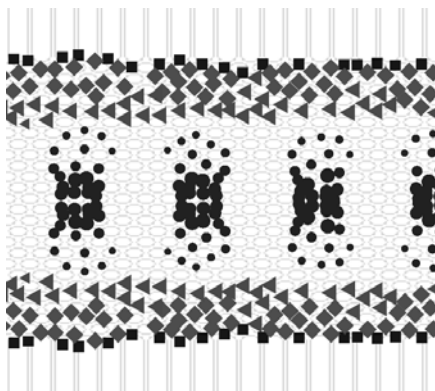
The aztec pattern may be formed as the result of spontaneous changes in destiny, in cells that normally all form the same blotch. There are often areas where cells appear to have "changed destinies" before the saddle has completely expanded, so that areas of ground color are formed instead of the saddle color. There can also be subdivided areas, as if parts of a single saddle have broken away from the main group to form their own smaller "independent" blotches.

There appears to be an area where some processes switch during the lateral (downward) migration. This line can be seen on normal corns as the place where the dark longitudinal lines form. It is also the place where the pattern ends on "whitesided" morphs of other species.

*(Dashed lines show dorsal/lateral dividing line).*



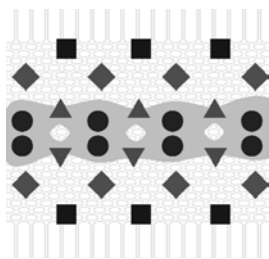
The main effect of the diffusion gene appears to alter the pattern starting at this point. Once cells reach this point, they seem to scatter in different directions instead of remaining in a single group. This results in an increasing amount of diffusion (blurring) of the pattern the further down the sides it goes. It may also slow the migration process at this point in time, as it appears to keep the belly checkers from reaching their destination, and also appears to thin the border areas.



The newly discovered pied-sided trait also appears to affect migration starting at this point. However, instead of scattering the pattern, it either stops or severely slows it. The parts of the pattern normally found all the way down on the belly are instead found on the sides of these corns. The areas beyond this are left a clean white color, creating an appearance as if the snake has been dipped in white paint. Additionally, migration does not always reach the end of the nose, which can leave white areas on the face. The same may be discovered on the tail.

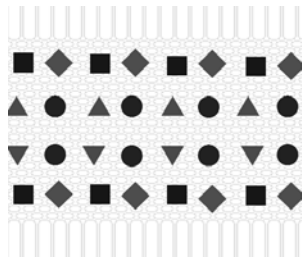


The motley locus, in this model, would appear to contain a gene that is responsible for some part of the lateral migration:



The motley mutation expresses itself as if it is slowing down the migration of all sideways movement. In effect, the entire pattern is "squished" toward the spine. The belly checkers are moved up to the edges of the scutes, leaving the belly a clean white. The lower side blotches form small squished blotches partway up the side. The upper side blotches only reach the edge of the saddle area, and (along with an apparent lengthening of the saddles) tend to cause the saddles to connect, forming a "ladder" pattern.

The stripe mutation expresses itself as a more extreme version of this effect. It causes the saddle and upper side blotches to only reach the edge of the saddle area, where they come together to form a line. It causes the belly and lower side blotches to only reach the center of the sides, forming a dotted or dashed line, or a complete lateral line. The migration appears to stop or severely slow at this point, which would be why the stripes are so thin, and "border" areas tend to be missing or reduced. The "cubed" pattern (and the squarish saddles on some striped corns) could result from some cells that are still able to divide as they migrate, creating the squarish markings.

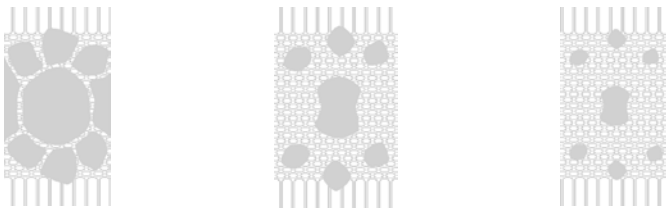


It has been previously thought that the checkerless bellies on motley, striped, and diffused corns was an additional effect. Based on the migration model, the effects of the motley, striped, and diffused mutants would be the *direct* cause of the lack of ventral checkering on those morphs.

Notice that with the three "lateral-slowng" genes (motley/stripe/diffusion) the head pattern, and the pattern on the side of the head can be affected. The "tiger bars" on the jaw can also be affected, since they are the head's "belly checkers."

The milksnake phase and banded lines of corns appear to be the result of selective breeding for the opposite effect of motley: they increase the amount of lateral migration, making broader saddles. This could explain why some motley and other "clear belly" snakes from these lines end up with unexpected belly checkers.

Additional traits may affect the expansion rates of the different elements of the pattern. For example: larger saddles, larger borders, and larger ground areas. Traits along these lines appear to exist in ball pythons, currently known as "spider" and "mojave" morphs, which brings hope that similar patterns may appear in corns.



*Different expansion rates can have a drastic effect on the pattern.*

Piebald, which is not known to exist in cornsnakes yet, prematurely kills off or deactivates migrating cells. This is responsible for the areas where no color or pattern develop. Several different species are known to have piebald mutants at a locus that corresponds to the same locus in the other species. (The locus is known as the endothelin-B receptor.) As a result, it is very likely that a piebald mutant will appear in cornsnakes someday and create that same phenotype. However, many of the mutants that cause piebaldism also cause severe or lethal effects on homozygotes. As a result, "bad" piebaldism might be discovered several times in a species before a "good" version is found.

Other pattern mutations (which have not yet been discovered) could affect the lengths and/or widths of saddles, the distances between saddles, the number of saddles, the thickness of the black border areas, and many other effects. It is the author's belief that brindle, leucistic, piebald, and whitesided pattern genes (and probably many others) will eventually appear in cornsnakes. Perhaps pied-sided is the cornsnake equivalent of other whitesided genes...

## Hybrids and Intergrades

Breeding cornsnakes to many other species of North American snakes has produced hybrids and intergrades. The two most common crosses are with Emoryi ratsnakes, and California kingsnakes.

### **Creamsicle** (\$40-60)

This term has two meanings:

- It is generically applied to any corn/emoryi cross to denote that it carries emoryi blood.
- It is specifically applied to amelanistic corn/emoryi individuals. The pictured example is amelanistic.



*Photo by Don Soderberg—  
South Mountain Reptiles*

Creamsicle projects are started by crossing an amel cornsnake to an emoryi (“great plains”) ratsnake. These offspring are then either bred to each other, or to an amelanistic cornsnake.

In the second generation and beyond, the amelanistic offspring (or any amel with an emoryi ancestor) are called creamsicles.

The name is a great description of their colors. They can have varying amounts of cornsnake versus emoryi blood, depending on whether they have been bred back to cornsnakes or to emoryi. The colors tend more toward red as more cornsnake is bred into the lines, and more yellow as more emoryi is bred into the lines.

### **Rootbeer** (\$ 40-50)

This name has more recently caught on as a name for corn/emoryi crosses that are not expressing any genetic traits. Several other traits, including hypo and motley, have been bred into these intergrades.

**Cinnamon (\$50-65)**

This name has been more frequently used to describe corn/emoryi crosses that are expressing the hypo trait. They have also been referred to as “hyposicles.”

**Jungle Corn (\$???, *varies greatly*)**

This name is applied to crosses between cornsnakes and California kingsnakes. These are **not** typically sterile, but it appears that they are not quite as fertile as either parent species. Second generation offspring (and beyond) have been produced from these hybrids. Amel, snow, motley, and other varieties of jungle corns are known to exist.

Other crosses have been made that include milksnakes, gopher snakes, bull snakes, and other North American colubrids. Corn X Honduran crosses are known as *corndurans*. Corn X gopher crosses are referred to as *turbo corns*.

## Coming Attractions

Many claims of “new” morphs are made each year. Almost all of them quickly disappear and are never heard of again.

If a “new” morph is based on a proven genetic trait, it will catch on sooner or later. The name coined by the originator/discoverer will often stick, but sometimes a “better” name will be applied and become more popular.

If a “new” morph is based on a selectively bred variation of an existing morph, it has to pass the market’s unofficial “brown bag” test in order to be accepted. The brown bag test works like this: put 25 miscellaneous corns, and 5 corns of this morph, all together in a brown paper bag. Then ask yourself, “Would the average buyer be able to sort through and pick out the 5 individuals of the new morph?” If not, it is unlikely to catch on as a new morph because people won’t remember it. In effect, enough people have to believe it is distinctive from existing variations that they will accept it as “new” and use the suggested name, earning it a place in the market and among hobbyists.

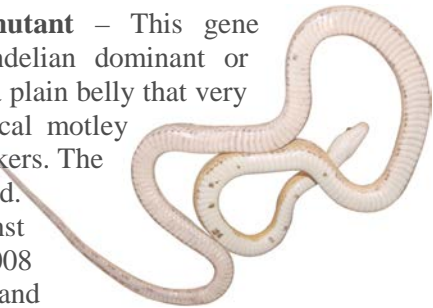

Some odd appearances are currently being investigated by different breeders, and could prove genetic within the next few years...

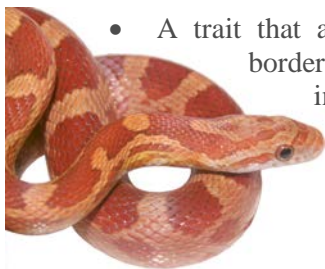
- **“Paradox Albino”** – Some amelanistic cornsnakes have some black areas. This is unexpected on an amelanistic cornsnake, but in some individuals it happens. Hence the name “paradox.” Pictured here is a snow with black spots on it.



*Photo by Sean Niland –  
VMS Professional Herpetoculture*

- A line of **patternless** corns is being test bred to determine how it is inherited. This could be the result of selective breeding. Another possibility is that this is another allele on the motley locus.

- **Unnamed plain belly mutant** – This gene appears to act as a Mendelian dominant or codominant gene, causing a plain belly that very closely resembles the typical motley belly, plus a few stray checkers. The dorsal pattern is not affected. Breeding trials against motley are planned for 2008 by Sean Niland, and outcrosses for 2009 by the author.
- **Strawberry** – Initially considered a “hypo-like” trait, breeding trials in 2005, 2006 and 2007 suggest that the gene is standard hypomelanism. An additional trial is planned for this year to verify previous results.
- **Christmas** – Another potential hypo-like gene, these have been proven as simple recessive. Test-crosses against other known “hypo-like” genes are being performed to verify.
- **“Piebald”** – Also called *pied*, this trait replaces random patches of the snake’s normal pattern with solid white. Although pied-sided has been proven as a genetic trait, “true piebaldism” has not yet been found in cornsnakes.
- **“Leucistic”** – A patternless white snake. This trait, like piebald, exists in many species and will inevitably show up in cornsnakes. However, it is also being brought into the cornsnake gene pool by hybridization with leucistic black ratsnakes and leucistic Texas ratsnakes.
- **“Wide Stripe”** – Several breeders are trying to determine the mode of inheritance of this aberrant pattern. So far it has shown it is not controlled by a simple dominant or codominant gene.
- Another similar looking aztec or wide-stripe pattern appears to be controlled by a simple codominant gene.



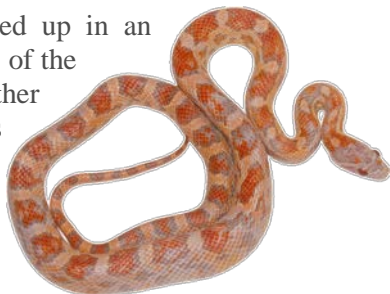
- A trait that appears to have a hypo-like and/or border reducing effect is being investigated. This is commonly found in keys/rosy corns but has never been put through breeding trials.

- **Golden Okeetee** – An odd corn with very little red and a lot of yellow coloration—similar to but not necessarily the same as caramel corns—was caught in the wild in North Carolina. Breeding trials to determine its heritability began in 2005. The gene proved recessive in 2006 when similar offspring were recovered in the F2. The other remaining test is to cross one against a caramel.
- **Snowflake** – The white spotting appears to be heritable as a mendelian recessive. This white spotting is not present at hatching, but comes in later as the snakes grow up.



*Photos by Sean Niland – VMS Professional Herpetoculture*

- A potential mimic of motley has appeared within a breeding group of lava-line corns in 2005. It appears (so far) that this trait is a simple recessive genetic trait, and that it is not at the same locus as motley.
- This *paradox* specimen showed up in an ultramel lavender project. Parts of the snake are lavender color and other parts are ultramel. Chimeras can have this type of appearance, and snakes occasionally hatch out with this type of oddity.



*Photo by Joe Pierce –CornSnakesAlive!*

People are always searching for new traits. This is always exciting, but problems can occur when it is assumed that all unusual appearances are caused by genetic traits. Here are some scenarios:

- An odd hatchling or hatchlings come from normal parents, and a breeder assumes it is a recessive trait and both parents are hets. The siblings not showing this “trait” are then labeled as “possible het” and sold at a premium.
- A breeder has a name applied to a line of selectively bred corns. A buyer or reseller who isn’t familiar with the name then sells the individual(s) with the name attached. The next person assumes it is a genetic trait and sells offspring as “hets.”

The problem is that the above scenarios are based on the assumption that anything with a name, or anything odd or unusual, is genetic. This is **not** a safe assumption, since many cornsnakes hatch out with odd patterns or colors due to any number of non-genetic causes. Unusual incubation conditions appear to be the most common cause.

In order for a trait to be proven genetic, it must be reproducible in some predictable way. The required breeding trials can take several years from the time the first specimen is discovered. A simple rule to go by is: *without grandchildren expressing the same look, it cannot be assumed to be a simple genetic trait.*

A recessive trait will not appear in the first generation of offspring, but will reappear when the normal-looking offspring are either bred to each other, or back to a parent.

A dominant or codominant trait will appear in the first generation, in either all the offspring, or about half of the offspring. However, selectively bred looks can also affect first generation offspring, so it is necessary to outcross further in order to determine what type of inheritance pattern it has. The next chapter explains this in detail.

Additionally, cornsnakes will be sold as hets for Miami, Okeetee, Green Spot, Hurricane, Keys, Kisatchie, Banded, Aztec, Zigzag, Candycane, and other selectively bred looks. Cornsnakes cannot be het for these qualities.



## Proving Mendelian Genes

Proving a gene as Mendelian (recessive, codominant, or dominant) is a great tool for morphing our corns and can add value to carriers of a gene, because it allows the new characteristic to be combined into the hundreds of existing morphs with predictable results. But the process can be a bit difficult to understand.

The first step is deciding if a trait or characteristic is interesting enough to try to prove it out. It can be anything you want, such as eye color, shapes of scales, speckled or smooth colors, elongated head, etc. It might also be a negative trait that people want to remove from their gene pools. If it is recessive, simply getting rid of affected individuals will only temporarily hide the problem and will make it much more difficult to deal with when it returns.

Next you need to locate a suitable mate. It is absolutely vital to choose a mate whose offspring will not mask the expression of whatever trait you are looking for, and whose offspring will not mimic the expression of that characteristic. For example, say you have found a snake with huge saddles and wish to find out if this is inherited in mendelian fashion. If you cross it to the largest-saddled snake you can find, even if the offspring have large saddles, you have no way of knowing which parent(s) contributed to that look. Conversely, if you cross it to a carrier of a patternless gene or a snake with unusually small saddles, you won't be able to tell if the saddles have been affected.

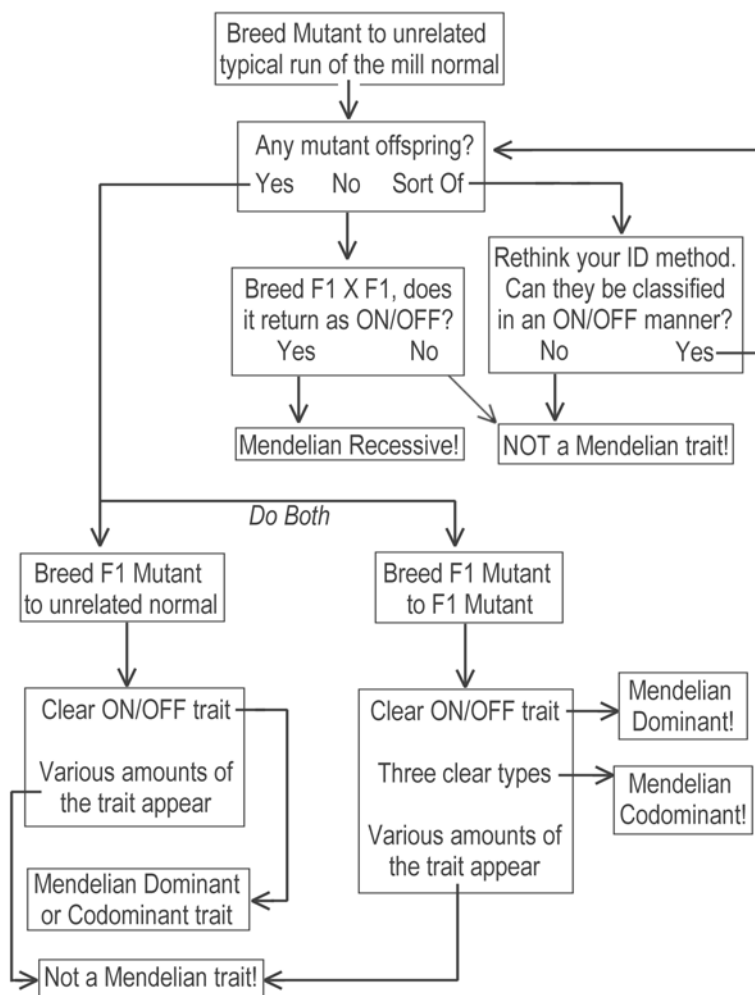
The ideal mate is a run of the mill, typical snake, or one that is expressing pattern or color genes which won't interfere with your ability to classify your hatchlings. For example, testing the motley gene can be done by crossing to a normal, a snow, a lavender, a butter, a phantom, or most other color morphs.

Once a suitable mate has been selected, you are ready to begin breeding trials. Know beforehand that you will need to produce grandchildren in order to prove an inheritance pattern. Use the following flow chart to work out your results.

When evaluating mutant or non-mutant, there should be little or no "between" states. The difference should be a very clear and easily-classified yes or no. For example, if you tried to identify motleys by

counting the number of connected saddles, the results would not be very clear and you might think it is a selectively bred trait. Meanwhile if you instead use the obvious yes/no belly pattern as the indicator, you can discover its mendelian recessive mode of inheritance quite easily.

Keep this in mind, and the possibility that what you consider “a trait” could be a complex of independent traits. You might need to rethink how you identify mutant versus non-mutant. This is most common in new wild-caught specimens, and can cause confusion when the breeder hangs on to the idea that the entire look of the snake is “a trait.”

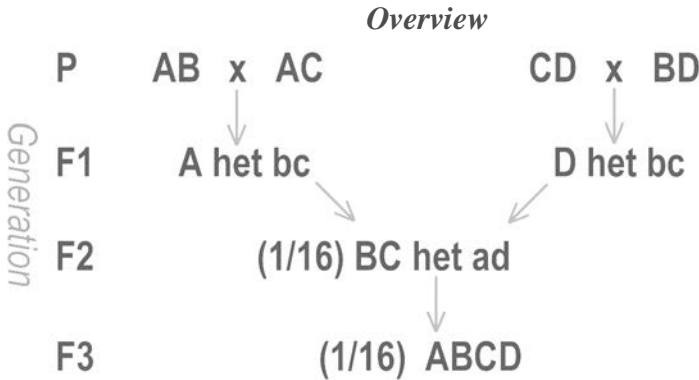


## Breeding Schemes

Double and triple genetic morphs are becoming more and more common. A few quadruple morphs are being produced, too. Many times these are produced by the brute force method of producing triple or quad hets and then keeping back large quantities to overwhelm the odds. This technique can be useful if you are willing and able to keep large numbers of snakes, or if you only want to dedicate your efforts toward a single project.

Following is a method which takes advantage of the current gene pool and clutch sizes, doesn't require the keeping of such large numbers of snakes, and allows diversification of projects. It can be used as is, or as a starting point for additional schemes to roll over genes into new combinations.

Imaginary recessive genes **A** through **D** will be used for this example. Say you want to produce a snake expressing all four genes (of morph **ABCD**) but they currently only exist as single morphs and double combinations. (**AB** and **BD** and **BC**, etc)



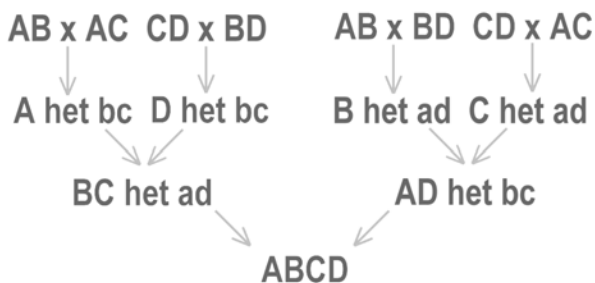
(P) Start out with double morphs. Crossing these (P) together in the right way produces (F1) snakes expressing one morph, and het for two others. Taking two separate lines of these (F1) with matching hets, you will then recover the hets while outcrossing the homos. Then you will have (F2) snakes homo for two morphs and het for two more, which you can use to produce your (F3) quad morphs.

The first advantage in this process is that you do not have to go beyond 1 in 16 odds. This is important, because it is not overly difficult or time-consuming, and does not require you to raise up and breed large numbers of snakes for a single project. You can defeat higher odds (1 in 64, for example) with larger groups, but then you end up producing many more normal and other common morphs, and you are left with less room for other projects.

The next advantage is that this system allows you to overlap the F1 and F2 from various projects, so that you can produce even more variety by intermixing different lines. For example if you also have a project involving gene E, you might have **E het bc** to go with **A het bc**, which can be a shortcut to a project producing **ABCE** corns.

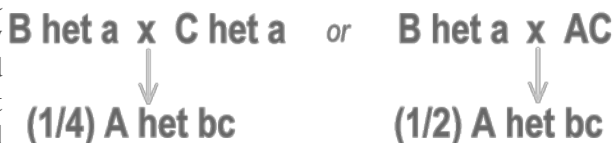
These snakes are also found in triple morph projects, for example when someone crosses a hypo lavender to a lavender motley, they produce lavenders het hypo motley. Watch for these genotypes, you might be able to find them for sale and skip the first generation.

Next, this plan can be expanded by swapping the mates from original crosses on the next year. In addition to producing **A het bc** and **D het bc**,



you can also produce **C het ad** and **B het ad**. This has the advantage of producing all known hets in the final generation, where the simpler plan produces 66% possible hets.

Another potential shortcut is available if you cannot find the double morph you need to start out with. For example if you want to cross **AB** to **AC** in order to produce **A het bc**, you can also drop the overlapping gene to a het in one or both mates. Your resulting clutch will not consist entirely of the desired offspring, but you don't need an entire clutch of them.



Finally, this plan can be used cooperatively between breeders. Different people can raise up and exchange counterparts along the way. If the different breeders use different stock for their starting point, there will be no inbreeding, which can help maintain the vigor of a bloodline. Cooperation also allows again for more projects to be run simultaneously, or for more individuals to be kept as a way to increase your chances of success.

An online calculator is available on the [cornguide.com](http://cornguide.com) website, (<http://cornguide.com/quads.php>) where you can fill in the four genes you wish to combine, check which combinations are available, and apply them to this plan.

You might find it easier to design your own such plan given what you have available to work with. When manipulating the plan, be sure to keep in mind that the advantage is gained through rolling over the double hets. The reason is that recovering Mendelian traits in this way gives a 1 in 16 chance per egg. It is reasonable to expect some success with a small number of clutches or even a single clutch. With those odds and a clutch of 16 eggs, you are about twice as likely to succeed as you are to fail.

The same rollover technique works on double hets whether they are single morphed, or even double or triple morphed, as long as the double hets are the same in both mates.

## Appendix A – Further Reading / Hyperlinks

A support website for this book is located at <http://cornguide.com>. A forum linked from the site allows readers to communicate with each other and the author with questions, comments, and feedback about this guide. An online genetics tutorial is there, too.

Online forums, where you can have a dialogue with other cornsnakers, and browse an ever-growing gallery of cornsnakes, are located at: <http://cornsnakesource.com>

Several handy programs (for Windows) that predict the outcomes of morph breedings exist. Three of them are on the web:

<http://mywebpages.comcast.net/spencer62/cornprog.html>

<http://www.kornnatterlexikon.de>

<http://www.cornsnakes.nl/>

The Corn Snake Manual, by Bill and Kathy Love contains a great deal of information about caring for and breeding cornsnakes, and historical information about the origins of many of the morphs, along with a lot of quality photos. It can be found at many bookstores and reptile shows, or you can order it online directly from the authors at: <http://cornutopia.com>

The second edition of the Corn Snake Manual, also by Kathy Love and Bill Love, is titled Corn Snakes The Comprehensive Owner's Guide and is also available (signed by the authors) at Kathy Love's [cornutopia.com](http://cornutopia.com) website.

Corn Snakes In Captivity by Don Soderberg was just released in October of 2006. <http://www.cornsnake.NET>

A Color Guide to Corn Snakes by Michael McEachern is an old but useful book. It can be found at [amazon.com](http://amazon.com).

A web search for cornsnakes will bring up a lot of breeders' sites. Many of them have pictures and information about the morphs they produce and sell. This is a good way to become familiar with the names and looks and varieties. The following websites are a good starting point:

**<http://cornsnakesource.com>** has Photo and Progression Galleries. *A progression follows a single snake as it grows up so you can see the colors change over the years.*

<http://www.serpwidgets.com/Morphs/morphs.html>

<http://herpreregistry.com/acr>

<http://cccorns.com/collection2008.php>

<http://cornsnake.NET/> (Both the price list and the photo gallery)

<http://cornutopia.com>

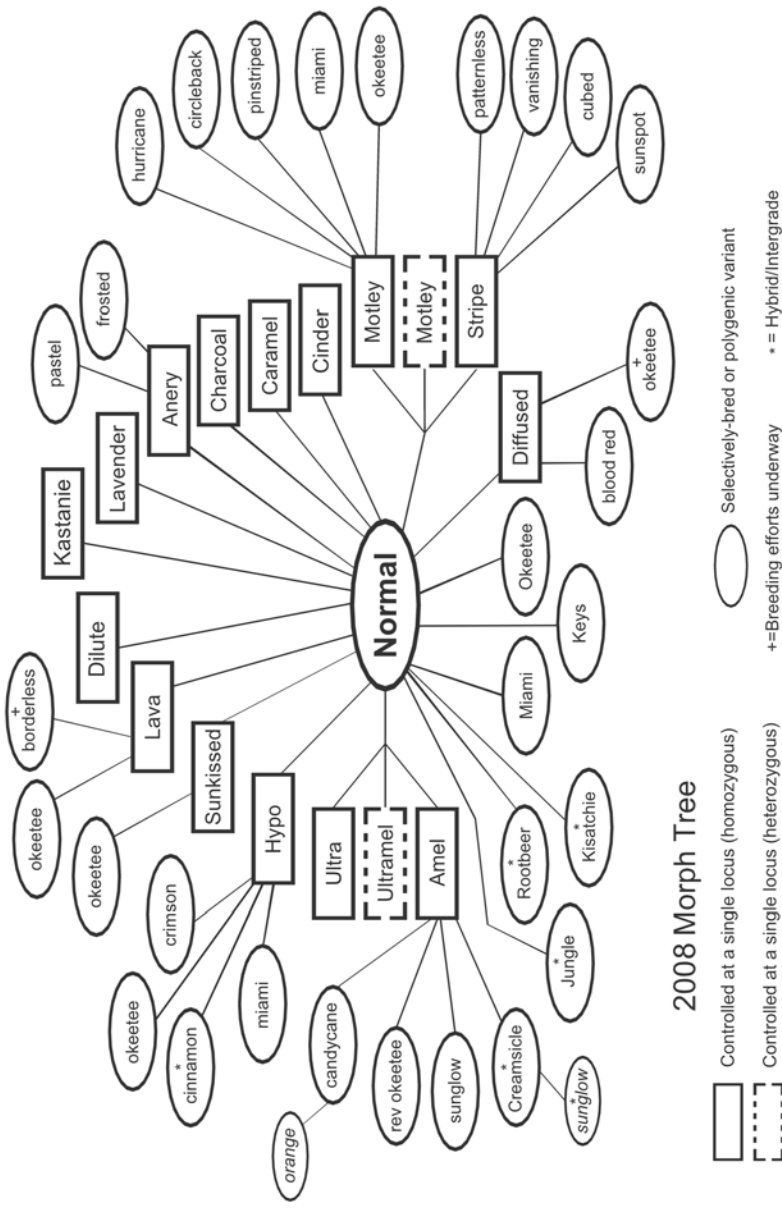
<http://vmsherp.com/>

<http://www.morphgallery.com>

<http://www.iansvivarium.pwp.blueyonder.co.uk/cornmorphs.html>

A list of links will be maintained at <http://cornguide.com>.

Appendix B – The Morph Tree





## The Morph Tree

The purpose of the morph tree is to illustrate the way that different morphs are related to each other. The tree originates with normal in the center. By following the lines outward, it is possible to “construct” a morph.

The rectangles represent morphs that are based on on/off genes. The dashed rectangles are instances of morphed corns that result from being heterozygous for two different mutant alleles at the same locus.

Note that two-locus combinations are not included in the tree, only genetic morphs based on genes at a single locus. Including combinations would make the map much more complex, and nearly impossible to read because branches would all interconnect to every other branch, like a spider web. This map is just the first “layer” of the world of corn morph possibilities. The Genetic Morphs chapter shows many of the two-gene combinations.

The ovals represent morphs that are created through selective breeding. Smaller ovals represent secondary selective breeding. For example, with candycanes, which are selectively bred, there are projects selecting among candycanes for the ones with orange saddles.

As time passes and new generations are hatched, the tree will gain more branches as new genes are discovered, and as new selectively bred variations are created within each genetic morph type. In 2007 the Dilute and Cinder genes were added. In 2008 the Kastanie gene was added. It is expected that christmas, terrazzo, and pied-sided will be added once their places among genes are worked out.

## Appendix C – Prices and Frequency of Morphs

*Frequency of single and double genetic morphs:*

	<i>Amel</i>	<i>Ultra</i>	<i>Hypo</i>	<i>Sunkissed</i>	<i>Lava</i>	<i>Aner</i>	<i>Charcoal</i>	<i>Caramel</i>	<i>Lavender</i>	<i>Diffused</i>	<i>Motley</i>	<i>Stripe</i>	<i>Cinder</i>	<i>Dilute</i>
<i>Amel</i>	C	U	*	r	r	C	C	C	C	U	C	C	r	
<i>Ultra</i>	U	U	?	r		r		U	r	r	U	r		
<i>Hypo</i>	*	?	C	r		C	C	C	C	U	U	U		
<i>Sun</i>	r	r	r	U	r		r	r	r		r			
<i>Lava</i>	r			r	U	U		r	r	r	r			
<i>Aner</i>	C	r	C		U	C	*	U	U	U	C	C		U
<i>Char</i>	C		C	r		*	C			U	r	r		
<i>Crml</i>	C	U	C	r	r	U		C	r	U	U	U		
<i>Lynd</i>	C	r	C	r	r	U		r	C	U	U	r		
<i>Diff</i>	U	r	U		r	U	U	U	U	C		r		
<i>Mot</i>	C	U	U	r	r	C	r	U	U		C	U		
<i>Strp</i>	C	r	U			C	r	U	r	r	U	C		
<i>Cind</i>	r												r	
<i>Dlt</i>						U								r

- Key:** C Common (*Easy to find and purchase*)  
 U Uncommon (*May be difficult to find and purchase*)  
 R Rare (*A handful or fewer specimens exist*)  
 Not known to exist  
 \* Probably common, but very few specimens identified.

Prices of single and double genetic morphs:

	Amel	Ultra	Hypo	Sun	Lava	Aner	Char	Crml	Lynd	Diff	Mot	Strp	Cind	Dlt
Amel	20-35	50-120	40-60			25-45	50-70	35-70	75-100	80-150	30-60	50-70		
Ultra	50-120	50-120				125-150		70-200	+++	+++	100-150			
Hypo	40-60		25-55	+++		25-50	45-90	50-60	100-125	100-150	35-70	75-100		
Sunkissed			+++	50-85										
Lava					65-150	175-225			+++					
Anery	25-45	125-150	25-50		175-225	20-40		60-80	80-100	85-125	50-65	50-65		125-200
Charcoal	50-70		45-90				30-40			80-125				
Caramel	35-70	70-200	50-60			60-80		20-40		+++	50-65	150-175		
Lavender	75-100	+++	100-125		+++	80-100			50-100	+++	120-200	+++		
Diffused	80-150	+++	100-150			85-125	80-125	+++	+++	60-90		+++		
Motley	30-60	100-150	35-70			50-65		50-65	120-200		30-40	30-60		
Stripe	50-70		75-100			50-65		150-175	+++	+++	30-60	45-60		
Cinder													+++	
Dilute						125-200								175

+++ Price very high and could vary between breeders and throughout the season.

*Prices of Other Morphs:*

<i>Triple Morphs</i>	<i>Price</i>	<i>Genetic makeup:</i>
Avalanche	175-250	Amel Anery Diffused
Snow Motley	45-80	Amel Anery Motley
Striped Snow	50-85	Amel Anery Striped
Butter Motley	50-125	Amel Caramel Motley
Striped Butter	+++	Amel Caramel Striped
Whiteout	+++	Amel Charcoal Diffused
Hypo Snow	40-60	Amel Hypo Anery
Diffused Opal	+++	Amel Lavender Diffused
Opal Motley	250-300	Amel Lavender Motley
Opal Striped	+++	Amel Lavender Striped
Dilute Anery Motley	125-170	Anery Motley Dilute
Ghost Motley	50-65	Hypo Anery Motley
Striped Ghost	60-90	Hypo Anery Striped
Hypo Granite	+++	Hypo Anery Diffused
Hypo Pewter	+++	Hypo Charcoal Diffused
Hypo Plasma	+++	Hypo Lavender Diffused
Hypo Lavender Motley	+++	Hypo Lavender Motley
Striped Hypo Lavender	+++	Hypo Lavender Striped
Golddust Motley	+++	Ultramel Caramel Motley

*Corn-Emoryi hybrids*

Creamsicle	40-60
Rootbeer	40-50
Cinnamon	50-65
Rootbeer Motley	60-70
Striped Creamsicle	100

*Variations of amels*

Candycane	50-60
Reverse Okeetee	40-50
Sunglow	40-60

*Variations of normals*



















Okeetee	30-60
Miami	25-45
Upper keys / Rosy Rat	30-50
Zigzag/aztec	40-55
Banded	50-85
Milksnake Phase	40-80
Kisatchie	70-80

*Selectively bred submorphs*

Crimson	40-50
Hypo Miami	25-100
Hypo Okeetee	40-80
Sunglow Motley	75-125
Pin-striped /	40-75
Q-tipped Motley	
Bloodred	60-150

## Appendix D – Answers to Genetics Practice Problems

### Page 12:

1. A   Normal	B   Normal	C   Shows Triangle trait
2. A   Shows Square trait	B   Shows Square trait	C   Normal
3. A   Shows Diamond trait	B   Normal	C   intermediate (Diamond/Normal)

### Page 25-26:

1 Aa.	2 Aa, aa.	3 Aa, AA.	4 AA, Aa, aA, aa.	5 AaBb.
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6-	<b>Aa</b>	<b>aa</b>
<b>Bb</b>	AaBb	aaBb
<b>bb</b>	Aabb	aabb

7-	<b>Aa</b>	<b>aa</b>
<b>BB</b>	AaBB	aaBB
<b>Bb</b>	AaBb	aaBb
<b>bB</b>	AabB	aabB
<b>bb</b>	Aabb	aabb

8-	<b>AA</b>	<b>Aa</b>	<b>aA</b>	<b>aa</b>
<b>BB</b>	AABB	AaBB	aABB	aaBB
<b>Bb</b>	AABb	AaBb	aABb	aaBb
<b>bB</b>	AAbB	AabB	aAbB	aabB
<b>bb</b>	AAbb	Aabb	aAbb	aabb

### 9- AaBbCc.

10-	<b>Aa</b>	<b>aa</b>
<b>Bb</b>	AaBbcc	aaBbcc
<b>bb</b>	Aabbcc	aabbcc

11- (step 1)	<b>Aa</b>	<b>aa</b>
<b>Bb</b>	AaBb	aaBb
<b>bb</b>	Aabb	aabb

11- (step 2)	<b>CC</b>	<b>Cc</b>
<b>AaBb</b>	AaBbCC	AaBbCc
<b>aaBb</b>	aaBbCC	aaBbCc

<b>Aabb</b>	AabbCC	AabbCc
<b>aabb</b>	aabbCC	aabbCc

12- (step 1)	<b>AA</b>	<b>Aa</b>	<b>aA</b>	<b>aa</b>
<b>BB</b>	AABB	AaBB	aABB	aaBB
<b>Bb</b>	AABb	AaBb	aABb	aaBb
<b>bB</b>	AAbB	AabB	aAbB	aabb
<b>bb</b>	AAbb	Aabb	aAbb	aabb

12- (step 2)	<b>CC</b>	<b>Cc</b>	<b>cC</b>	<b>cc</b>
<b>AABB</b>	AABBCC	AABBCC	AABBcC	AABBcc
<b>AABb</b>	AABbCC	AABbCC	AABbCc	AABbcc
<b>AAbB</b>	AAbBCC	AAbBCC	AAbBcC	AAbBcc
<b>Aabb</b>	AabbCC	AabbCC	AabbCc	Aabbcc
<b>AaBB</b>	AaBBCC	AaBBCC	AaBBcC	AaBBcc
<b>AaBb</b>	AaBbCC	AaBbCC	AaBbCc	AaBbcc
<b>AabB</b>	AabBCC	AabBCC	AabBcC	AabBcc
<b>Aabb</b>	AabbCC	AabbCC	AabbCc	Aabbcc
<b>aABB</b>	aABBCC	aABBCC	aABBcC	aABBcc
<b>aABb</b>	aABbCC	aABbCC	aABbCc	aABbcc
<b>aAbB</b>	aAbBCC	aAbBCC	aAbBcC	aAbBcc
<b>aAbb</b>	aAbbCC	aAbbCC	aAbbCc	aAbbcc
<b>aaBB</b>	aaBBCC	aaBBCC	aaBBcC	aaBBcc
<b>aaBb</b>	aaBbCC	aaBbCC	aaBbCc	aaBbcc
<b>aabb</b>	aabbCC	aabbCC	aabbCc	aabbcc

13- aa =  $\frac{1}{4}$ . bb =  $\frac{1}{2}$ . cc =  $\frac{1}{2}$ , dd =  $\frac{1}{4}$ . Total is 1 in 64.

14- aa =  $\frac{1}{2}$ . bb =  $\frac{1}{2}$ . cc =  $\frac{1}{2}$ . dd =  $\frac{1}{2}$ . Total is 1 in 16.

15- aa =  $\frac{1}{4}$ . bb =  $\frac{1}{4}$ . cc =  $\frac{1}{4}$ . dd =  $\frac{1}{4}$ . Total is 1 in 256.

16a- aa =  $\frac{1}{4}$ . bb =  $\frac{1}{4}$ . Total is 1 in 16.

(Ax means Aa, aA, or AA.)

(Dx means Dd, dD, or DD.)

16b- Ax =  $\frac{3}{4}$ . bb =  $\frac{1}{4}$ . cc =  $\frac{1}{4}$ . Dx =  $\frac{3}{4}$ . Total is 9 in 256.

## Appendix E – Glossary

**Allele** – Any of the variants that can occur at a given locus. See also: *gene*.

**Amelanistic** – A condition of having no melanin. See also: *melanin*.

**Anerythristic** – A condition of having no erythrin. See also: *erythrin*.

**Autosomal** – A locus that is found on paired chromosomes, as opposed to the sex chromosomes. Loci are assumed autosomal unless otherwise stated. See also: *Mendelian*.

**Codominant** – A relationship between two alleles where both are expressed when they are heterozygous together. When a codominant/codominant pair of alleles are shown in all three configurations, there are three resulting phenotypes.

**Cross Multiply** – A method of determining the four possible outcomes of a cross at a single locus. See also: *Punnett square*, *FOIL*.

**Diploid** – A cell that contains chromosomes in pairs. Almost all cells in an animal's body are diploid. See also: *haploid*.

**Dominant** – A gene that, when present in a pair, is the only one expressed. When a dominant/recessive pair of alleles are shown in all three configurations, the dominant allele completely controls the phenotype where it is present. See also: *recessive*.

**Erythrin** – The red pigment in cornsnakes. See also: *anerythristic*.

**FOIL** – A method of determining the four possible outcomes of a cross at a single locus. See also: *cross multiply*, *Punnett square*.

**Gene** – A term that can be used interchangeably with locus or allele. Its meaning depends on the context of its use. See also: *locus*, *allele*.

**Genome** – One complete set of chromosomes. An individual animal possesses a pair of genomes.

**Genotype** – The alleles present at a given locus or loci. See also: *phenotype*.

**Haploid** – A cell that only contains one genome, instead of a pair. Sperm and egg cells are haploid. See also: *Diploid*.

**Het** – An abbreviation for *heterozygous*.

**Heterozygous** – Unlike alleles at a locus. It is mutually exclusive to homozygous. See also: *homozygous*.

**Homo** – An abbreviation for *homozygous*.

**Homozygous** – Identical alleles at a locus. It is mutually exclusive to heterozygous. See also: *heterozygous*.

**Hybrid** – Any cross between two unrelated individuals. Most often used to describe crosses between two different species, or members of two different genera.

**Hypomelanistic** – When the pigment *melanin* is reduced in quantity or quality. See also: *melanin*.

**Incomplete Dominant** – A type of codominance: a relationship between two alleles where both are partially expressed when they are heterozygous together. When such a pair of alleles are shown in all three configurations, there are three resulting phenotypes. See also: *codominant*.

**Intergrade** – 1: a cross between two species or subspecies in the wild. 2: the result of several generations of interbreeding between species or subspecies. 3: a cross between two similar species or subspecies in captivity.

**Line Breeding** – A type of selective breeding where related individuals are crossed in an effort to fix a trait. See also: *selective breeding*.

**Locus** – A location, on a particular chromosome, where a particular set of alleles reside. See also: *gene*.

**Melanin** – A pigment, mainly responsible for the blacks/browns on corns. See also: *amelanistic*, *hypomelanistic*.



**Mendelian** – A trait that follows certain expression patterns because it is controlled by a pair of genes, one inherited from each parent. See also: *autosomal*.

**Phenotype** – The outward appearance (size, shape, color, temperament, etc.) of a specimen. See also: *genotype*.

**Possible het** – A label used to designate that a specimen has a certain statistical chance of being heterozygous for a particular recessive gene.

**Punnett Square** – A method of determining the four possible outcomes of a cross at a single locus. The father's first gene is combined with each of the mother's genes, then the father's second gene is combined with each of the mother's genes. See also *cross multiply*, *FOIL*.

**Recessive** – An allele that is not expressed when paired with a dominant allele. When a dominant/recessive pair of alleles are shown in all three possible configurations, the recessive allele only controls the phenotype where it is homozygous. See also: *dominant*.

**S-factored** – Indicates that an individual is a proven carrier of the stargazer mutant.

**Selective Breeding** – A breeding program where individuals showing a certain look are bred to each other in order to enhance that look. See also: *line breeding*.

**Xanthin** – A pigment, mainly responsible for yellows on corns.

**Zygote** – A fertilized egg.

## Appendix F – Morph Name Cross-Reference

### A

**Albino** – *See Amelanistic.*

**Albino Okeetee** – *See Reverse Okeetee.*

**Amel** – *See Amelanistic.*

**Amelanistic** – Homozygous for amel at the albino locus.

**Amelanistic Okeetee** – *See Reverse Okeetee.*

**Anery** – *See Anerythristic.*

**Anery A** – *See Anerythristic.*

**Anery B** – *See Charcoal.*

**Anerythristic** – Homozygous for anery at the anery locus.

**Avalanche** – Genetic combination of amel & anery & diffused.

**Aztec** – Selective breeding for pattern involving aberrant angular markings.

### B

**Banded** – Selective breeding for pattern with saddles extend toward belly.

**Black Albino** – *See Anerythristic.*

**Blizzard** – Genetic combination of amel & charcoal.

**Blood** – *See Bloodred.*

**Bloodred** – Diffused plus selective breeding for borderless and extreme red.

**Bullseye** – *See Hurricane Motley.*

**Butter** – Genetic combination of amel & caramel.

### C

**Candycane** – Amelanistic plus selective breeding for white ground color.

**Caramel** – Homozygous for caramel at the caramel locus.

**Charcoal** – Homozygous for charcoal at the charcoal locus.

**Charcoal Ghost** – 1: genetic combination of anery & charcoal & hypo.  
2: genetic combination of charcoal & hypo.

**Christmas** – Unproven hypo-like recessive trait.

**Cinder** – Homozygous for cinder at the cinder locus.

**Cinnamon** – Hypomelanistic plus emoryi hybrid.

**Circleback Motley** – Motley with saddles connecting all the way to the vent, forming circles of ground color.

**Coral Snow** – 1: genetic combination of amel & anery & hypo.  
2: genetic combination of amel & anery, plus selective breeding for extreme coral colors.

**Cornduran** – Hybrid of corn and Honduran milksnake.

**Creamsicle** – Amelanistic plus emoryi hybrid.

**Crimson** – Hypomelanistic plus selective breeding.

**Cubed** – Striped plus variation/selective breeding for square saddles.

### D

**Diffused** – Homozygous for diffusion at the diffused locus.

**Diffused Okeetee** – Diffused plus selective breeding for heavy bordering and bright orange ground color.

**Donut** – *See Hurricane Motley.*

**Dream** – Hypomelanistic plus selective breeding for Okeetee-like traits.

**F**

**Fire** – Genetic combination of amel and diffusion.

**Four-lined Stripe** – *See Striped.*

**Frosted** – 1: Selective breeding for dithering/frosting of saddle colors.

2: Denotes hybridization with gray rat snakes.

**G**

**Ghost** – Genetic combination of hypo & anery.

**Ghost Motley** – Genetic combination of hypo & anery & motley.

**Golddust** – Genetic combination of ultra/ultramel & caramel.

**Granite** – Genetic combination of anery & diffusion.

**Green Blotched Snow** – Genetic combination of amel & anery, plus variation/selective breeding for green tinted saddles.

**H**

**Hunt Club** – Denotes locality of origin as the Okeetee Hunt Club.

**Hurricane Motley** - Motley plus selective breeding for faded out saddle interior and boldly outlined saddles.

**Hybino** – Genetic combination of amel & hypo.

**Hypo** – *See Hypomelanistic.*

**Hypo A** – *See Hypomelanistic.*

**Hypo Miami** – Hypomelanistic plus selective breeding for Miami-phase.

**Hypo Okeetee** – Hypomelanistic plus selective breeding for Okeetee phase.

**Hypomel** – *See Hypomelanistic.*

**Hypomelanistic** – Homozygous for hypo at the hypo locus.

**I**

**Ice** – Genetic combination of anery & lava.

**J**

**Jungle** – Hybrid of corn and kingsnake, usually California king.

**K**

**Keys** – *See Upper Keys.*

**Kisatchie** – Rat snake Species, also considered intergrade of corn x emoryi.

**L**

**Lava** – Homozygous for lava at the lava locus.

**Lavamel** – Genetic combination of amel & lava.

**Lava Okeetee** – 1: Lava descended from locality Okeetees. 2: Lava plus selective breeding for Okeetee-like traits.

**Lavender** – Homozygous for lavender at the lavender locus.

**Locality Okeetee** – Locality-specific or descended from locality stock, the locality being the Okeetee Hunt Club, or Jasper County, SC.

**Look-eetee** – *See Okeetee Phase.*

**M**

**Miami** – *See Miami Phase.*

**Miami Motley** – Motley plus selective breeding for Miami-like traits.

**Miami Phase** – Normal plus selective breeding for a clean light gray (non-orange/tan) ground color.

**Milksnake Phase** – Normal plus selective breeding for banded saddles and light ground color.

**Mocha** – *See Lavender.*

**Motley** – Homozygous for motley at the motley locus.

**Motley/striped** – 1: Motley plus variation/selective breeding for a pattern with pinstriped, or q-tip markings. 2: Heterozygous for motley and stripe at the motley locus.

**MSP** – Abbreviation for Milk Snake Phase.

## N

**No-White Amel** – Amelanistic plus selective breeding for lack of white saddle areas.

**Normal** – 1: Not expressing any of the known genes. 2: Having normal coloration. 3: Having normal patterning.

## O

**Okeetee** – 1: *See Okeetee Phase.* 2: *See Locality Okeetee.*

**Okeetee Motley** – Motley plus selective breeding for Okeetee-like traits.

**Okeetee Phase** - Normal plus selective breeding for Okeetee-like traits.

**Opal** – Genetic combination of amel & lavender.

**Orange Candycane** - Amelanistic plus selective breeding for white ground color and orange saddles.

## P

**Pastel** – Applied in many different ways to anerythrastics of many genotypes and breeding. Please refer to individual using it.

**Pastel Ghost** - Applied in many different ways to anerythrastics of many genotypes and breeding. Please refer to individual using it.

**Pastel Motley** - Applied in many different ways to anerythrastics of many genotypes and breeding. Please refer to individual using it.

**Patternless** – Striped plus selective breeding for stripes that disappear. (Potentially a genetic combination, but “patternless gene” is still undergoing breeding trials.)

**Pepper** – *See Pewter.*

**Pewter** – Genetic combination of charcoal & diffusion.

**Phantom** – Genetic combination of hypo & charcoal.

**Pied-sided** – Either genetic combination of diffusion & pidedsided, or homozygous for pidedsided at the diffused locus. (Breeding trials underway)

**Pink and Green Snow** - Genetic combination of amel & anery, plus variation/selective breeding for green tinted saddle borders, plus either pink ground color and/or pink saddle color.

**Pinstriped Motley** – Motley plus variation/selective breeding for pinstriping.

**Plasma** – Genetic combination of lavender & diffusion.

## R

**Red Albino** – *See Amelanistic.*

**Reverse Okeetee** - Amelanistic plus selective breeding for thickened border areas and extreme orange ground color.

**Rootbeer** – Normal plus emoryi hybrid.

**Rosacea** – Elpaha guttata rosacea. *See Upper Keys.*

**Rosy** – 1: *See Hypomelanistic.* 2: *See Upper Keys.*

**Rosy Ratsnake** - *See Upper Keys.*

## S

**Slowinskii** – Pantherophis slowinskii. *See Kisatchie.*

**Snow** – Genetic combination of amel & anery.

**Strawberry** – Unproven hypo-like trait.

**Stripe/Motley** – *See Motley/striped.*

**Striped** – Homozygous for striped at the motley locus.

**Striped Motley** - *See Motley/striped.*

**Sulfur** – Genetic combination of amel & caramel & diffusion.

**Sunglow** – Amelanistic plus selective breeding for no borders and extreme orange ground color.

**Sunglow Motley** – Genetic combination of amel & motley, plus selective breeding for no borders and extreme orange ground color.

**Sunkissed** – Homozygous for sunkissed at the sunkissed locus.

**Sunkissed Okeetee** – Sunkissed plus selective breeding for Okeetee-like traits.

**Sunspot** – Motley or stripe plus variation/selective breeding for oval-shaped saddles.

## T

**Terrazzo** – Homozygous Terrazzo at its locus.

**Topaz** – Genetic combination of lava & caramel.

**Transparent Hypo** – *See Lava.*

**True Okeetee** – *See Locality Okeetee.*

**Turbo** – Hybrid of corn and gopher snake.

## U

**Ultra** – Homozygous for ultra at the albino locus.

**Ultramel** – Heterozygous for ultra and amel at the albino locus.

**Upper Keys** – Locality-specific, although many of these are descended out of stock from the *lower* Florida Keys.

## V

**Vanishing Stripe** – Striped plus variation/selective breeding for striping that fades out as the snake matures.

## W

**Whiteout** – Genetic combination of amel & charcoal & diffusion.

**Wide Stripe** – Unproven pattern trait, creates an aztec pattern which often consists of connected saddles forming a wide wavy dorsal stripe.

**Wild-type** – *See Normal.*

## Z

**Z** – *See Cinder.*

**Zigzag** – Variation/selective breeding for a pattern where the left/right halves of the saddles are offset, creating a zigzag.

**Zipper** – *See Zigzag.*

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**The 2008 Edition, fifth in the continuing series, includes the kastanie and terrazzo genes. New sections include breeding shortcuts to make multi-morphs and how to prove Mendelian genes.**



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