Rat Genetics

Ellie Holtaway

Rats are one of the most amazing creatures on this planet. They live among us, in our shadows. They feed off of our waste. They are one of the most adaptable of all mammals, they have been found on every continent and breeding populations are recorded on all except Antarctica. The reason rats are such a successful species is mostly contributed to the fact that they reproduce so easily. A rat can become fertile at as young as six weeks old, and give birth to up to 14 babies in a single litter, seven times per year.

Because of their fast reproduction rate, scientists are drawn to them for experiments. Using rats is especially common in science because in a relatively short period, you can use selective breeding to create animals that are either substantially genetically different from one another, or rats that are practically genetically identical. Geneticists could study genes by selectively breeding for one specific trait and observing changes over time, while other scientists could use a large number of genetically similar animals to test environmental variables or drug side effects.

The lives of humans and rats have been connected for longer than one would assume. In fact, rats have been living in the shadows of human populations since we first began farming and storing grains. Based on archeological evidence, it is assumed that the population of early rats exploded around the same time that the first farms formed. Humans, trying to protect their crops, then began performing an unusual sport. To try to control the rat populations, the wealthy class in early Victorian England would capture a large number of wild rats and place them into a pit with a terrier dog. Bets could be placed on dogs, collecting a large profit for the establishments. The owner of the dog that killed the most rats the fastest was crowned the winner.

Because natural mutations in wild populations is so common for rats, it is assumed that some uniquely colored rats passed through rat pit establishments. It is suspected that humans removed unique individuals and breed them together, increasing the occurrences of these mutations. After a while, they began to see rats with unique patterns and new fur colors such as albino, black, fawn, and grey. These rats were sold into the pet trade around 1840. Around the same time, colored mice were also finding their way into the pet trade, and the National Mouse Club was formed in 1895.

In 1905, Miss Mary Douglas contacted the National Mouse Club (England) to inquire about the possibility of them accepting rats into their club. The National Mouse Club accepted her suggestion and added rats to their club, and Miss Mary Douglas became know as the ‘mother of fancy rats’.

It wasn't until 1978 that fancy rats first found their way to America. The Mouse and Rat Breeders Association was formed in 1978, and the American Fancy Rat and Mouse Association in 1983. Since then, breeders have been working to improve the rat by developing standards for body type, behavior, colors, and fur. Over time, breeders have been able to identify specific genes in the rat that control certain physical traits.

I wanted to find out more about how genetic traits are passed on through the generations, so I decided to breed two rats. I wanted to know how rats can give birth to babies that look so different from each other, and form the parents. Before this project, I thought that the color of baby rats was completely random, because all litters are so diverse. But after reading the American Fancy Rat and Mouse Association's *Rat Genetics* and *Breeding Rats* books, I had a much clearer understanding. It turns out that the color of baby rats is not random at all, in fact it is quite easy to predict what color your litter might be.

I started my project by purchasing a doe (female) from a reputable breeder (Lisa, Doll Baby Rattery). The female is a brown heavily marked variegated with a face spot. I named her Domino, but her original name is DBR Victoria. I brought Domino home to give her some time to adjust to a new house and a new rat family (I have two other rats), before sending her to another breeder to meet her mate. I first sent Domino to another breeder who I knew (Jozzette, Jozzy's Rat Pack Rattery) to mate with one of her bucks, but Domino did not get pregnant. So, she went back to Lisa who had a male (originally from Jozzy). The male was gorgeous! He was a sky blue (color - light gray) bristle coat (rough coat) dumbo (ears) buck (male).

Domino did get pregnant from DBR Wolverine (the buck). The only issue was that it is really difficult to tell when female rats are pregnant, they only start to show when they are about to give birth. So, on the day that I drove up to Riverside to bring Domino home, she gave birth. I did not want to stress her out by moving her while she was giving birth, so I stayed up in Riverside until that night when the labor was over. She had a little bit of trouble with the birth. She had 3 babies in the morning, then 2 more later that night. One of the two that was born that night was dead at birth, and the other one was substantially smaller than normal. That baby also passed away the next day. But the three that were born in the morning were very healthy, and she was taking care of them, so I transported the family home.

Watching the babies grow up was one of the most amazing things I have ever had the opportunity to experience. It was amazing how in just a few weeks, they went from tiny blind, deaf, hairless, little babies to crazy, curious, social animals. At first I could not believe how fast they were growing, it seemed like they doubled in size every day! By the second day, they were already showing pigment in their skin, and by day 4 they started getting some fur. Now the three of them live together without their mom, and are ready to go to their new homes.

There are two types of pigment that control the color of a rat's coat color. Eumelanin causes black or brown, and phaeomelnin causes a yellow or red color. There are many different genes that control the combination, density, and distribution of those two pigments, and I have outlined those genes below. Rats, as a species, also have polygenes, which modify the specific gene, such as changing the shade of a color.

Using the American Fancy Rat and Mouse Association's *Rat Genetics* book, I was able to figure out exactly what Domino and Wolverine's genomes look like. This is not their entire genome, it is just the section responsible for coat appearance.
(The colored genes are the ones that are different from each other and would affect the babies. The - stand for either recessive or dominant.)

Domino
aa bb C- D- G- mm meme P- pepe R- ii

Wolverine
aa B- C- D- gg M- meme P- pepe R- I-

Once I had this helpful baseline, I could use the results from the breeding (what traits the babies have) to figure out if a dominant or recessive gene fits into the loci marked with a (-).

In order to figure this out, I created simple charts to predict the outcome. The top row represents Domino's genes, and the first column represents Wolverines genes. The four boxes each 'inherit' one letter from each parent. I used the letters in each box to figure out the percentage of babies that would have certain traits.

- The Agouti Locus (A) controls the distribution of yellow pigment in the hair. A dominant agouti locus makes each hair striped. Because Domino and Wolverine both have two recessive genes in the Agouti locus, I know that none of the babies will be agouti.

- The brown locus (B) determines if the eumelanin will be expressed as brown or black in the coat. B (dominant) is black and b (recessive) is chocolate. Because I do not know if a dominant or recessive gene occupies the second spot on Wolverine's B locus, I use a chart to figure out the answer.

Black Locus

Scenario 1:

- Domino bb
- Wolverine BB

	b	b
B	Bb	Bb
B	Bb	Bb

100% Black

Scenario 2:

- Domino bb
- Wolverine Bb

	b	b
B	Bb	Bb
b	bb	bb

50% Black, 50% Brown

Because some of the babies are brown, and some are black, I know that a recessive b must occupy the second spot on Wolverine's brown locus.

- Next is the albino locus (C) this locus causes both pigments (eumelanin and phaeomelanin) to be diluted. There are a few variations to this locus:

C - Full color

c^{ch} - Chinchilla

c^{h} Acromelanism (Siamese)

c - Albino

None of the babies appear to be chinchilla, siamese, or albino, but that does not necessarily mean Domino and/or Wolverine are not carriers. Because they have C (dominant) paired with any variation, they appear as full color.

- The dilute locus (D) is a recessive gene that causes pigments to be globbed together in clumps. Rats with a D (dominant) gene will appear to have normal color, but if they have two d (recessive) genes, they will appear spotted. Again, Domino or Wolverine have for sure one D (dominant) dilute gene, but that does not necessarily mean they are not carriers of the d (recessive) dilute gene. None of the babies inherited this trait.

- The next locus, the grey locus (G) produces what is called ‘blue’ in the fur. It makes the rat’s fur grey, and if two dominant genes are inherited, it will mask the dominant black from the B locus.

Gray Locus

Scenario 1:

- Domino GG
- Wolverine gg

	G	G
g	Gg	Gg
g	Gg	Gg

100% full color - no dilution

Scenario 2:

- Domino Gg
- Wolverine gg

	G	g
g	Gg	gg
g	Gg	gg

50% full color, 50% gray/blue

Because one of the babies is gray/blue, I know that Domino must have a recessive (g) occupying the second gene in the gray locus.

- The next Locus, the Mink Locus (M) is responsible for the color black to be diluted to a gray/brown color.

Mink Locus

Scenario 1:

- Domino mm
- Wolverine MM

	m	m
M	Mm	Mm
M	Mm	Mm

100% full color

Scenario 2:
- Domino mm
- Wolverine Mm

	m	m
M	Mm	Mm
m	mm	mm

50% full color, 50% mink

It is not possible to identify this gene for sure, because none of the babies are mink, which could either mean that Wolverine has a dominant M dominant M, or that he has a dominant M recessive m and all of the babies just happened to inherit the dominant M.

- The merle locus (Me) causes irregular blotches of dark color on a light background. Rats who inherit the dominant gene Me (dominant) will appear similar to a merle dog. Rats who inherit the me (recessive) gene will be non merle. Neither Domino and Wolverine are merle, so they must have both received two recessive copies of the merle gene.

- The pink-eye locus (P) causes the pigment in the eyes to be diluted form a black/brown to a light pink. Rats who received at least one P (dominant) gene will have black eyes, while rats who received two copies of the p (recessive) gene will have pink eyes. Domino and Wolverine both have black eyes, so they have at least one copy of the P (dominant) gene. They could be carriers of the p (recessive) gene, but none of the babies inherited that trait.

- Pearl locus (Pe) is responsible for changing the hair color to white, leaving a colored tip. Pearl is a dominant gene, so rats with at least one copy of the Pe (dominant) will have pearl coloring. A rat would have to inherit two copies of the pe (recessive) gene to have normal/standard hair. Domino and Wolverine both have standard coats, so they must both have two recessive copies of the pearl gene.

- The red eye locus (R) is very similar to the pink eye locus (P), except it dilutes the pigments less. Rats who have two copies of r (recessive) will have ruby colored eyes. Rats who inherit one or more R (dominant) copies will have black eyes. Domino and Wolverine both have black eyes, so they have at least one copy of R (dominant) each. If they were carriers of the r (recessive) gene, none of the babies inherited it.

- Bristle Coat is fairly new to the fancy rat world, and the particular gene patterns have not been fully identified yet. Breeders do know that the bristle coat gene is dominant, so based on that information I formulated my own equation. Keep in mind that it is very possible for this trait to be controlled by multiple genes, but for the purpose of this paper, I will assume it is one.

Bristle Coat

Scenario 1:

- Domino ii
- Wolverine II

	i	i
I	Ii	Ii
I	Ii	Ii

100% Bristle Coat

Scenario 2:

- Domino ii
- Wolverine Ii

	i	i
I	Ii	Ii
i	ii	ii

50% Bristle Coat, 50% Standard

Because only two of the three babies have bristle coats, I know that wolverine must have had a recessive i in occupying the second gene.

Final Genes

Domino

aa bb C- D- Gg mm meme P- pepe R- ii

Wolverine

aa Bb C- D- gg M- meme P- pepe R- Ii

Please refer to my blog: Rat Breeding Blog for my daily logs during the project.