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Every year as spring draws near I begin to hear the familiar refrain of 'what will I get if I cross a black and a chocolate' or 'what will I get if I cross a palomino and a black'. Unfortunately, the question just creates more questions that need answered to get a thorough answer. While in a perfect world color would not be a determining factor in breeding, in today's market the color of the foal can be the difference between getting top dollar or having to just about give the foal away. As the market for horses tightens and supply increases, breeders have become increasingly interested in breeding for specific colors. In the past, the color of choice was always chocolate with a white mane and tail, but in recent years I've seen an increased interest in other colors.

To thoroughly answer the question of what we will get when we cross two horses, I have to know not just the color of your horse but also what hidden color genes you horse might have. I usually break the task up into several parts. The first is to figure out the base coat colors (black, bay, or chestnut), then what modifier genes (silver dapple, cream, roan, grey, dun) were needed to create the colors seen in the horses. Table 1 contains the 'color formulas' for many of the popular colors. The table shows the base coat color and the modifier gene needed to create the color. Table 2 contains a list of the most common modifier genes as well as how the gene affects the horse's color. The base coat color is controlled by two genes. The first determines if the horse can produce the color black on its body at all (bays and blacks) or if it will be all red (chestnuts). The scientists refer to this gene as the Extension gene so you will see it symbolized with an 'E' on the color DNA tests to refer to the dominant of the gene (produces black) or an 'e' for the recessive (red) version of the gene. The second gene determines if the black on the horse will be only on the points (bay) or over the entire horse (black). This gene is called the Agouti gene. The dominant of the gene ('A') produces bay and the recessive ('a') produces black.

Table 1. Color Formulas

Modifier Gene	Base Coat Color		
	Black	Chestnut	Bay
Silver Dapple	Chocolate	Chestnut (no affect)	Red Chocolate
Cream (one)	Smokey Black (little or no affect – basically black)	Palomino	Buckskin
Cream (two)	Smokey Cream	Cremello	Perlino
Roan	Blue Roan	Red Roan	Bay Roan
Gray	Gray (born black)	Rose Gray (born chestnut)	Gray (born bay)
Dun	Grullo	Red Dun	Dun
Champagne	Classic Champagne	Golden Champagne	Amber Champagne

Once we know the base coat and modifier genes present in the horses to be bred, we then need to figure out what might be hidden. So this second step is to figure out the

hidden genes for the base coat. For this we have to ignore the modifier genes, so if I talk about a black, bay or chestnut then that includes any of the colors in that column in the color formulas table. Depending on the base color of your horse, different genes can be hidden. For instance a black or bay might be carrying a recessive gene to produce chestnut.

Table 2. Modifier Gene's Affect on Coat Color

Modifier Gene	**Action**
Silver Dapple	Causes black on the body to be diluted to brown and causes black in the mane and tail to be diluted to flaxen. It is not unusual for the mane and tail to darken as the horse ages. The red color on the horse's body is not affected.
Cream (one)	The red on the body is diluted to gold and red in the mane and tail is diluted to ivory. The black on a horse is not usually affected or only lightened slightly. Skin on the muzzle, around the eye and on genitals is dark except where there are white markings. The skin might be pink when the foal is initially born but darkens within a week or two.
Cream (two)	The horse will have pink skin and blue eyes. The red on the horse is diluted to cream (almost white but with a slight golden tint if not sun faded). The black on the horse is diluted to a cream, rust or orange tint.
Roan	The horse will have white hairs mixed in on the body. The head and lower legs will not be frosted. The mane and tail may have some frosted guard hairs but will be basically solid colored. Foals may be born roan or may turn roan when their foal coat sheds. Roans change the amount of frosting with the seasons but will not progressively whiten over the years. To produce a roan foal, at least one parent MUST be roan.
Gray	The foal is usually born a solid body color and progressively grays out until all of its hair turns white. Unlike the roan gene, the gray gene will also produce white hairs on the face, lower legs, mane and tail. Also unlike the roan gene this is a progressive gene with the horse getting lighter in color until it turns white. To produce a gray foal, at least one parent MUST be a gray.
Dun	This gene lightens both the red and black hairs on a horse's body. The mane, tail and legs are darker. The dun gene also causes the presence of primitive markings, which are a shade or two darker than the body color. Primitive markings include a dorsal stripe; leg barring; cobwebbing on the face; or a shoulder stripe. To produce a dun foal, at least one parent MUST be a dun.

Champagne	This gene lightens both the red and black hairs on a horse's body, mane and tail. Black on the body is turned a brownish gray. Black in the mane and tail are turned to dark brown. Red on the body is turned to a golden color. Red in the mane and tail can be turned gold or white. Champagne foals are usually born darker then their final color (this is opposite of most modifier genes). They are born with pink skin that develops mottling fairly quickly, especially on the muzzle, around the eyes and on the genitals. They are usually born with blue eyes that darken as they age to amber (can be anything from yellowish green to medium brown but not as dark as a normal eye). This gene is commonly confused with the cream gene. To produce a champagne foal, at least one parent MUST be a champagne.

If EITHER of its parents is a chestnut OR if it has EVER produced a chestnut then it must carry the recessive gene for it. A bay might also be hiding the recessive gene to produce a black as well as the recessive gene to produce chestnut. Once again if EITHER of its parents is a chestnut OR if it has EVER produced a chestnut then it must carry the recessive gene for chestnut. If EITHER of the bay horse's parents is a black OR if it has EVER produced a black then it must carry the recessive gene for black. Because a chestnut does not have any black on its body, you can not tell looking at the horse if it will produce black or bay. If BOTH parents were black then you know that the offspring carries two genes to produce black. If ONE parent was black then you know that the offspring will carry at least one gene to produce black. In the past, if we had not owned the horse its entire life, we were unlikely to know the answer to the above questions. Now that the RMHA's pedigree database is online, we can investigate the colors of not only your horse's parents, but also any of their registered foals. The database can be accessed through the RMHA web site at www.rmhorse.com. In SOME cases this can answer the above questions. If you still can't figure out what hidden genes your horse carries then there is always the option of pulling some tail hairs and sending them off to have DNA color testing done, but this gets expensive for a large herd. The alternative is to make some educated guesses based on what the 'typical' genetic makeup is for a Rocky Mountain Horse.

Table 3 shows the current color breakdown for the Rocky Mountain Horse. The category 'Other' takes in all the misspellings and varieties where there is only one entry in the database. As you can see, chocolate is the most abundant color followed by black. Based on the data, it can be assumed that at least 32% of the non-chestnut herd carries the red gene since about half that number are either chestnut or palomino. Note that I said at least 32% carry the gene because I recognize that in the past many breeders did not bother to register a foal if it was a chestnut, so the number could be much higher. Bays, Buckskins and Red Chocolates make up about 18% of the non-chestnut herd. Since the bay base color is dominant, 18% of the chestnuts can be assumed to carry a bay gene (that means that 82% do not), but the 18% once again may be a little low.

Table 3. Rocky Mountain Horse Herd Colors

Color	Percent
Chocolate	48.13
Black	19.09
Chestnut/Sorrel	13.19
Red Chocolate	6.48
Bay	6.37
Palomino	2.45
Buckskin	1.51
Roan (blue,chocolate,red,bay)	0.95
Other	0.88
Gray	0.31
Dun/Grullo	0.31
Cremello	0.23
Champagne	0.10

What all this means is that if you don't want to spend the money for color DNA testing and you still don't know enough by looking up the parents and offspring of the horse then you can still make some educated guesses and have a good chance of being right. MOST chestnuts will carry the genes to produce black instead of bay; MOST bays will carry one gene to produce black. These are pretty sure guesses because the percentage of bay horses in the association is so low. The red gene on the other hand is present in a much higher percentage of horses. If you have a bay or black base coat color horse, neither parent was chestnut and the horse has not produced a chestnut, then the most accurate way of predicting if the horse carries the red gene is to look up the other offspring of the horse's parents in the online database. If EITHER parent EVER produced a foal with a chestnut base coat color (chestnut, sorrel or palomino) then you have a 50/50 chance of the horse in question carrying the red gene. If BOTH parents had produced chestnut base coat colored offspring then the odds go up to 67% that your horse will carry the red gene. If neither parent is shown to have produced any chestnut offspring then assume until proven otherwise that the horse in question does not carry the red gene.

The last information that needs to be figured out is the hidden modifier genes. The most common of these would be the silver dapple gene. As can be seen on Table 2, the silver dapple gene does not affect the color red on a horse, so any of the chestnut base coat colors will hide this gene. If the horse has EVER produced a chocolate or red chocolate when bred to a black or bay horse then you know that the horse carries the silver dapple gene. If NEITHER of the parents of the horse were chocolate, red chocolate, chestnut, or palomino then your chestnut horse can not carry silver dapple (for instance the chestnut offspring of breeding two blacks). If neither of these tests give you an answer then you should assume that your chestnut carries the silver dapple gene since over 60% of the RMHA herd appears to carry the gene. The one other modifier gene that could be hidden is the cream gene on a black based color. Fewer then 10% of the herd appears to carry the cream gene, so assume that that they don't carry it unless they have produced a palomino or buckskin when bred to a bay or chestnut. It is a commonly known fact that

the foundation stallion, Maple's Squirrel, did carry the cream gene, so his direct offspring have a 50/50 chance of carrying the cream gene if they are chocolate or black.

Now that you know not just the color of the horses you plan to breed, but what hidden genes they carry, go to Table 4. Because of space considerations, I could not list all possible breeding combinations. Across the top I listed what appears to be some of the more common colors found in the association. Down the side I listed both the more common colors and several not so common.

Table 4. Expected Outcome of Typical Breeding Crosses

	Chocolate (one silver dapple, no red gene)	**Chocolate (one silver dapple, red gene)**	**Chocolate (two silver dapple, no red gene)**	**Black (no red gene)**	**Black (carries red gene)**	**Chestnut (no bay, one silver dapple gene)**	**Chestnut (no bay, no silver dapple gene)**	**Bay (one black, no red gene)**	**Red Chocolate (one black, no red gene)**
Chocolate (one silver dapple, no red gene)	75% Chocolate 25% Black (note 25% will be ASD)	75% Chocolate 25% Black (note 25% will be ASD)	100% Chocolate (note 50% will be ASD)	50% Chocolate 50% Black	50% Chocolate 50% Black	75% Chocolate 50% Black (note 25% will be ASD)	50% Chocolate 50% Black	25% Chocolate 25% Black 25% Red Chocolate 25% Bay	37.5% Chocolate 37.5% Red Chocolate 12.5% Black 12.5% Bay (note 25% will be ASD)
Chocolate (carries one silver dapple, and red gene)	75% Chocolate 25% Black (note 25% will be ASD)	56.25% Chocolate 25% Chestnut 18.75% Black (note 25% will be ASD)	100% Chocolate (note 50% will be ASD)	50% Chocolate 50% Black	37.5% Chocolate 37.5% Black 25% Chestnut	50% Chestnut 37.5% Chocolate 12.5% Black (note 25% will be ASD)	50% Chestnut 25% Chocolate 25% Black	25% Chocolate 25% Black 25% Red Chocolate 25% Bay	37.5% Chocolate 37.5% Red Chocolate 12.5% Black 12.5% Bay (note 25% will be ASD)
Chocolate (2 silver dapple, no red gene)	100% Chocolate (note 50% will be ASD)	100% Chocolate (note 50% will be ASD)	100% Chocolate (note 100% will be ASD)	100% Chocolate	100% Chocolate	100% Chocolate (note 50% will be ASD)	100% Chocolate	50% Chocolate 50% Red Chocolate	50% Chocolate 50% Red Chocolate (note 50% will be ASD)
Black (no red gene)	50% Chocolate 50% Black	50% Chocolate 50% Black	100% Chocolate	100% Black	100% Black	50% Chocolate 50% Black	100% Black	50% Black 50% Bay	25% Chocolate 25% Black 25% Red Chocolate 25% Bay

	Chocolate (one silver dapple, no red gene)	**Chocolate (one silver dapple, red gene)**	**Chocolate (two silver dapple, no red gene)**	**Black (no red gene)**	**Black (carries red gene)**	**Chestnut (no bay, one silver dapple gene)**	**Chestnut (no bay, no silver dapple gene)**	**Bay (one black, no red gene)**	**Red Chocolate (one black, no red gene)**
Black (carries red gene)	50% Chocolate 50% Black	37.5% Chocolate 37.5% Black 25% Chestnut	100% Chocolate	100% Black	75% Black 25% Chestnut	50% Chestnut 25% Chocolate 25% Black	50% Black 50% Chestnut	50% Black 50% Bay	25% Chocolate 25% Black 25% Red Chocolate 25% Bay
Red Chocolate (one silver dapple, one black, no red gene)	37.5% Chocolate 37.5% Red Chocolate 12.5% Black 12.5% Bay (note 25% will be ASD)	37.5% Chocolate 37.5% Red Chocolate 12.5% Black 12.5% Bay (note 25% will be ASD)	50% Chocolate 50% Red Chocolate (note 50% will be ASD)	25% Chocolate 25% Black 25% Red Chocolate 25% Bay	25% Chocolate 25% Black 25% Red Chocolate 25% Bay	37.5% Chocolate 37.5% Red Chocolate 12.5% Black 12.5% Bay (note 25% will be ASD)	25% Chocolate 25% Black 25% Red Chocolate 25% Bay	37.5% Red Chocolate 37.5% Bay 12.5% Chocolate 12.5% Black	56.25% Red Chocolate 18.75% Bay 18.75% Chocolate 6.25% Black
Chestnut (no bay, no silver dapple gene)	50% Chocolate 50% Black	50% Chestnut 25% Chocolate 25% Black	100% Chocolate	100% Black	50% Black 50% Chestnut	100% Chestnut	100% Chestnut	50% Black 50% Bay	25% Chocolate 25% Black 25% Red Chocolate 25% Bay
Palomino (no bay, no silver dapple gene)	50% Chocolate 50% Black	25% Palomino 25% Chestnut 25% Chocolate 25% Black	100% Chocolate	100% Black	50% Black 25% Palomino 25% Chestnut	50% Palomino 50% Chestnut	50% Palomino 50% Chestnut	50% Black 25% Buckskin 25% Bay	25% Chocolate 25% Black 12.5% Chocolate Buckskin 12.5% Red Chocolate 12.5% Buckskin 12.5% Bay

	Chocolate (one silver dapple, no red gene)	**Chocolate (one silver dapple, red gene)**	**Chocolate (two silver dapple, no red gene)**	**Black (no red gene)**	**Black (carries red gene)**	**Chestnut (no bay, one silver dapple gene)**	**Chestnut (no bay, no silver dapple gene)**	**Bay (one black, no red gene)**	**Red Chocolate (one black, no red gene)**
Buckskin (no red, one black gene)	25% Chocolate 25% Black 12.5% Buckskin 12.5% Chocolate Buckskin 12.5% Red Chocolate 12.5% Bay	25% Chocolate 25% Black 12.5% Buckskin 12.5% Chocolate Buckskin 12.5% Red Chocolate 12.5% Bay	50% Chocolate 25% Chocolate Buckskin 25% Red Chocolate	50% Black 25% Buckskin 25% Bay	50% Black 25% Buckskin 25% Bay	25% Black 25% Chocolate 12.5% Buckskin 12.5% Chocolate Buckskin 12.5% Bay 12.5% Red Chocolate	50% Black 25% Buckskin 25% Bay	37.5% Buckskin 37.5% Bay 25% Black	18.75% Buckskin 18.75% Chocolate Buckskin 18.75% Red Chocolate 18.75% Bay 12.5% Chocolate 12.5% Black
Cremello (no silver dapple gene)	50% Chocolate 50% Black	50% Palomino 25% Chocolate 25% Black	100% Chocolate	100% Black	50% Black 50% Palomino	100% Palomino	100% Palomino	50% Black 50% Buckskin	25% Chocolate 25% Black 25% Chocolate Buckskin 25% Buckskin
Cremello (carries bay, no silver dapple gene)	25% Chocolate 25% Black 25% Chocolate Buckskin 25% Buckskin	50% Palomino 12.5% Chocolate Buckskin 12.5% Buckskin 12.5% Chocolate 12.5% Black	50% Chocolate Buckskin 50% Chocolate	50% Buckskin 50% Black	50% Palomino 25% Buckskin 25% Black	100% Palomino	100% Palomino	75% Buckskin 25% Black	37.5% Chocolate Buckskin 37.5% Buckskin 12.5% Chocolate 12.5% Black
Perlino (one black, no silver dapple, no red gene)	25% Chocolate 25% Black 25% Chocolate Buckskin 25% Buckskin	25% Chocolate 25% Black 25% Chocolate Buckskin 25% Buckskin	50% Chocolate 50% Chocolate Buckskin	50% Black 50% Buckskin	50% Black 50% Buckskin	25% Black 25% Chocolate 25% Buckskin 25% Chocolate Buckskin	50% Black 50% Buckskin	75% Buckskin 25% Black	37.5% Chocolate Buckskin 37.5% Buckskin 12.5% Chocolate 12.5% Black

	Chocolate (one silver dapple, no red gene)	**Chocolate (one silver dapple, red gene)**	**Chocolate (two silver dapple, no red gene)**	**Black (no red gene)**	**Black (carries red gene)**	**Chestnut (no bay, one silver dapple gene)**	**Chestnut (no bay, no silver dapple gene)**	**Bay (one black, no red gene)**	**Red Chocolate (one black, no red gene)**
Smokey Cream (no silver dapple, no red gene)	50% Chocolate 50% Black	50% Chocolate 50% Black	100% Chocolate	100% Black	100% Black	50% Black 50% Chocolate	100% Black	50% Buckskin 50% Black	25% Chocolate 25% Black 25% Chocolate Buckskin 25% Buckskin
Smokey Cream (one silver dapple, no red gene)	75% Chocolate 25% Black (note 25% will be ASD)	75% Chocolate 25% Black (note 25% will be ASD)	100% Chocolate (note 50% will be ASD)	50% Black 50% Chocolate	50% Black 50% Chocolate	75% Chocolate 25% Black (note 25% will be ASD)	50% Black 50% Chocolate	25% Chocolate Buckskin 25% Buckskin 25% Black 25% Chocolate	37.5% Chocolate 37.5% Chocolate Buckskin 12.5% Buckskin 12.5% Black
Blue Roan (no red gene)	25% Blue Roan 25% Chocolate Roan 25% Black 25% Chocolate	25% Blue Roan 25% Chocolate Roan 25% Black 25% Chocolate	50% Chocolate Roan 50% Chocolate	50% Blue Roan 50% Black	50% Blue Roan 50% Black	25% Blue Roan 25% Black 25% Chocolate Roan 25% Chocolate	50% Blue Roan 50% Black	25% Blue Roan 25% Black 25 % Bay Roan 25% Bay	12.5% Blue Roan 12.5% Black 12.5 % Bay Roan 12.5% Bay 12.5% Chocolate Roan 12.5% Chocolate 12.5% Red Chocolate Roan 12.5% Red Chocolate

	Chocolate (one silver dapple, no red gene)	**Chocolate (one silver dapple, red gene)**	**Chocolate (two silver dapple, no red gene)**	**Black (no red gene)**	**Black (carries red gene)**	**Chestnut (no bay, one silver dapple gene)**	**Chestnut (no bay, no silver dapple gene)**	**Bay (one black, no red gene)**	**Red Chocolate (one black, no red gene)**
Blue Roan (carries red gene)	25% Blue Roan 25% Chocolate Roan 25% Black 25% Chocolate	18.75% Blue Roan 18.75% Chocolate Roan 18.75% Black 18.75% Chocolate 12.5% Chestnut 12.5% Red Roan	50% Chocolate Roan 50% Chocolate	50% Blue Roan 50% Black	37.5% Blue Roan 37.5% Black 12.5% Chestnut 12.5% Red Roan	25% Chestnut 25% Red Roan 12.5% Blue Roan 12.5% Black 12.5% Chocolate Roan 12.5% Chocolate	25% Blue Roan 25% Black 25% Chestnut 25% Red Roan	25% Blue Roan 25% Black 25 % Bay Roan 25% Bay	12.5% Blue Roan 12.5% Black 12.5 % Bay Roan 12.5% Bay 12.5% Chocolate Roan 12.5% Chocolate 12.5% Red Chocolate Roan 12.5% Red Chocolate