Color Genetics

Elsie Darrah is a TWHBEA director from Kansas and long-time walking horse breeder. For ten years she has studied equine color genetics with the goal of identifying all colors found in the TWH breed. Following is a condensation of the booklet she is creating to help breeders accurately identify their foals' colors. Supported by the staff at UC Davis and Dr. Phillip Sponenberg, her goal is for a more accurate color identification system to be accepted by the TWHBEA and its membership. The author can be reached at twhcolors@hotmail.com. She welcomes ideas and suggestions.

"Our eyes tell us what a horse appears to be...
His pedigree tells us what he ought to be...
But his offspring tell us what he is!"

Understanding horse color enables us to identify horses accurately. Accurate identification of a horse's color is the key ingredient in understanding the genetic basis of color. We all recognize that in the Tennessee Walking Horse breed there is a wide variety of colors. The two main groups of horse colors are those with black points (mane, tail, lower legs and ear rims) and those with non-black points. The specific combination of point color and body color are what determines most horse colors. Another thing to consider is that white in markings and patterns are not the absence of all color but rather is white superimposed on what would have been the specific body or point color. A horse's final color results from the interaction of several independent processes, which can dilute, modify or restrict color. Hopefully you will appreciate if I leave out the technical terms and put it in everyday simple terms.

Genes are the basic units of genetic characteristic inheritance. All characteristics, including color, are inherited through pairs of genes, located on chromosomes, in the nucleus of every cell of the parent. However, each egg and each sperm cell from the individual producing them has only one of the alleles (alternative forms of the gene) for each characteristic. So the offspring gets one allele of each gene from the mother, and one allele of each corresponding gene from the father, resulting in a pair of alleles for every gene for each characteristic.

Horses have multiple pairs of color genes with the **upper case letter being the dominant gene** and the **lower case letter being the recessive gene.** A horse receives one gene of each pair of genes from each parent and the combinations of the genes received determine the base color, dilution, modification or color pattern for the resulting foal. Only one gene codes base color (chestnut or black), and the rest dilute, modify, restrict color or superimpose a white pattern on that base color Each foal is unique because the same mating can produce completely different results in subsequent foals. There are genes that code for coat color. The letters used to identify each gene are a fairly universal scientific notation protocol.

TERMS USED TO DESCRIBE GENES:

Dominant - Always physically expressed on the horse and require that at least **one** parent must express that gene in order to pass it on.

Recessive - Can be hidden and requires **both** parents to contribute a copy of the gene for it to be expressed.

Homozygous - A foal received one dominant copy of the same gene (AA, EE, aa, ee) from each parent. They in turn will always pass one copy of the gene to each of their offspring.

Heterozygous - A foal received a dominant copy from one parent and a copy of the recessive gene from the other parent, which means that foal will pass one (either the dominant or recessive) gene to its offspring.

BASE COLOR GENES

Black/Red (E,e) There are just two base colors: black & red (chestnut). Absolutely EVERY horse gets a combination of black (E, dominant) and/or red (e, recessive) alleles to produce their base color. ALL horses have either black base color or red base color.

ee - Homozygous for red (**ee**). The basic color is sorrel or chestnut.

Ee - Heterozygous for the red factor (**Ee**). It can transmit either **E** or **e** to its offspring. The basic color of the horse will be black, bay or brown.

E - Homozygous for black pigment (**EE**). It cannot have red foals, regardless of the color of the mate. The basic color of the horse will be black, bay or brown.

NOTE: Color coat testing is now available to identify of all of the above.

Brown The dominant pangare (**PP or Pp**) produces lighter colored areas around the muzzle, eyes, flanks, and the insides of the legs. This gene alters the black coat color to seal brown.

NOTE: Color coat testing is not available to identify yet but brown horses have an agouti and although they appear black their test results are the same as a bay.

Equine Color is like

MODIFYING GENES

Agouti / bay gene (AA, Aa, aa) is one of the most important factors in the determination of horse color because it controls the distribution of black pigment. The dominant allele **A** restricts black pigment to the points of the horse (mane, tail, lower legs and ear rims), as seen, for example, in bays and buckskins. The recessive allele **a** uniformly distributes black pigment over the entire body.

A or **Aa**: Black pigment distributed in point pattern. Basic color of the horse will be bay or brown in the absence of other modifying genes. **A** has no effect on red pigment (**ee**).

a: recessive allele allows Black pigment to be distributed uniformly. The basic color of the horse will be black in the absence of other modifying genes.

Grey (G) is a dominant color modifier, which mixes white hairs on a base coat color. It is a progressive modifier that gradually causes a coat to get lighter until it is almost white or has the "flea bitten" appearance with small spots of the original base coat color. A horse that is grey must have a grey parent and is always expressed or the horse didn't get a grey gene and can't pass it on to its foals. Foals are never born grey and so the color change on registration should show the modifier by adding grey and not change the base color, i.e., black/grey, chestnut/grey Grey is a progressive gene and foals are never born grey but they may have subtle signs such as grey eyelashes long before the grey expresses itself.

Roan (R) is a dominant color modifier gene and not a color. Roan modifies any coat color by mixing white hairs with the body coat and leaves the head, legs, mane and tail dark like the base color, i.e., black roan, chestnut roan, buckskin roan, etc. Roan horses remain the same color their entire lives with the exception of their winter coat, which is usually darker like the points and doesn't display the roaning until they shed off each spring. Roan horses must always have a parent displaying the roan modifier. **ANY** base color can be modified by the roan gene.

White (W, dominant) Genetic modifier that excludes all color from the coat. Very rare if, indeed, it exists. ALL dominant White horses must have dark eyes and pink skin and at least one White parent. They are not albino and there is no such thing as albino in horses. Nearly all TWH horses that are registered as white are actually maximum sabino, cremello, cream champagne or tobiano with very little spotting.

DILUTION GENES

1. Cream (**Cr**) Dilutes any base color to a paler version except it has no effect on black. .

Bay) + 1 cream gene = **Buckskin** + 1 cream gene = **Perlino**

Black + 1 cream gene = **Smoky Black** + 1 cream gene = **Smoky Cream**

Chestnut + 1 cream gene = **Palomino** + 1 cream = **Cremello**

Single dilute colors are born the dilute color and the only changes will be the shade of the coat color when they shed off the foal coat. Single dilute horses must have at lease one parent (single or double dilute) who contributes a cream gene.

Double dilute colors will **ALWAYS** have blue eyes and pink skin and will be born that color and remain that color throughout their lives. Double dilute horses receive a cream gene from each parent which means that both parents must be either a single dilute (buckskin, palomino, smoky black, cream champagne) or a double dilute (perlino, cremello or smoky cream) in order to contributes a cream gene to the foal.

NOTE: Color coat testing is available to determine if horse has one, two or no cream genes

2. Champagne (Ch, dominant) Affects coat, skin & eye color as well as coat texture & sheen of any base color.

Bay + champagne gene = **Amber**

Champagne + 1 cream gene = **Amber Cream**

Black + champagne gene = **Classic**

Champagne + 1 cream gene = **Classic Cream**

Chestnut + champagne gene = **Gold**

Champagne + 1 cream gene = **Gold Cream**

Champagne foals regardless of color are born dark like their base coat color with pink skin and blue eyes, which change to hazel or amber and the coat color lighten to the champagne coat color when they shed the foal coat. The pink skin develops freckling on the skin around the eyes, on the nose, under the tail and on the udder of mares and sheath of stallions and geldings.

Champagnes further diluted by breeding to a cream dilute are now referred to as cream, which more accurately describes their genetic color. They can appear to be a cremello, perlino or smoky cream, however they will have only one cream gene. Testing for the cream gene by UC Davis will verify they are cream champagne rather than double cream dilutes. They are born cream color with blue eyes but the color of the eyes will change to green/gray/amber and is distinctive from the blue eyed double dilute.

Building Blocks

by Elsie Darrah

3. Silver Gene (Z, dominant) Dilutes & dapples black based coat color & dilutes mane & tail color. It dilutes the black points on bay giving the impression of a chestnut with a flaxen or near white mane and tail, but when color tested will have a black gene and an agouti gene. It has no effect on chestnut (Red) and remains hidden until bred to a horse that carries a black gene to contribute to the foal who can express the silver gene. ALL Silver Gene horses must have a parent carrying the Silver gene even if not seen as in a red base. There is no specific test for the silver gene but there are several Tennessee Walkers who have been tested to determine their base color (one looks chestnut w/flax mane and tail and tested as homozygous for black which means it is a bay silver

4. Dun (D, dominant) **Dominant dilution gene** and always has a dorsal stripe down the spine, transverse stripe across the withers and stripes around the legs. Dun horses have rarely been documented in the Tennessee Walking Horse. It can be imposed on any base color, single or double dilutes or champagne colors. **ALL** Dun horses **must** have at least one dun parent and cannot skip generations. This gene is almost non-existent in Tennessee Walking Horse breed,

COAT PATTERNS

Color Patterns found in the TWH are tobiano, sabino, overo & tovero. They are dominant genes and are always expressed although sometimes in minimal form. Spotted patterns can be any one or a combination of patterns on any coat color. **Identification of all color patterns must be preceded by the base color not covered by white. Correct color of tobiano or overo to use, i.e., bay tobiano, bay sabino, bay overo, or bay Tovero, etc. Dilution genes and/or Color modifiers of roan or grey may also be present and modify the base color, i.e., black roan tobiano/grey or chestnut tobiano/sabino or buckskin/grey. There are many color pattern and color modifying combinations possible but it is important to always identify the base color (coat color) and then add the modifying pattern.**

1. Tobiano is a dominant gene and normally has spotting patterns with smooth edges with the head being dark and having normal face markings and rarely have blue eyes. The white crosses the top line and it can be boldly expressed or it can be minimally expressed with a few white hairs in the mane or tail and high white stockings that are above the hocks on the back legs and above the knees on the front legs. Tobianos that have small dark spots called "paw prints" within the white spots are most times homozygous for the tobiano pattern. A tobiano must have at least one tobiano parent.

2. Sabino is a dominant gene and very common in TWHs. They can have white from the ground up with excessive white on face, legs, belly, sides and neck. The white is irregular and edges appear fuzzy. They can be solid or roan. **Sabino is believed to be a dominant gene and cannot skip generations.** Sabinos can be easily identified by the bald face with white under the chin, jaw and with the white face extending around one or both eyes. Blue eyes are also common. Sabinos with stockings that don't extend all the way up to the body will usually have an inverted "V" where the white stops on the front side of the back legs and on the back side of the front legs. Another sign of sabino is white on the knees that looks like it was splashed on in a irregular pattern. Some Sabinos will only display the bald face with white on the jaws and under the chin with little or no body spots. One key marker on a sabino is the bald face and head markings especially white which extend below the lips and under the chin.

3. Overo can have white on the belly, sides, neck and face **without** crossing the top line. They usually have dark legs with regular socks and stockings. The head usually is excessively white and is sometime completely white except for the top of the head and ears.

4. Tovero is a combination of tobiano and overo or sabino and will present a combination of color patterns from the tobiano, overo and sabino patterns. It is most distinctive in the amount of white on the head, which has excessive white except for the top of the head and ears. Tobiano does not express itself with excessive white on the head or with glass eyes. Tovero is a combination and requires that one parent be a tovero or that one parent was a tobiano and the other an overo or sabino. There are very few true overos in the TWH and it would appear that Tobiano/Sabino color pattern combinations are common since so many spotted breeders bred tobianos to sabinos to ensure a greater percentage of spotted foals. The Tobiano/Sabino combination tends to produce a large percentage of sabino foals that are really loud colored but do not get the tobiano gene.

I hope this proves helpful as a guide for selecting the correct color for new foals and to correct past errors on color choices. Hopefully we will soon have the new color brochure finalized and available soon, plus an expanded version in a full color booklet with pictures. I have created a Foal Registration Worksheet to aid in making the correct color choices when registering a foal. Contact me at twhcolors@hotmail.com for a copy.