Color Genetics

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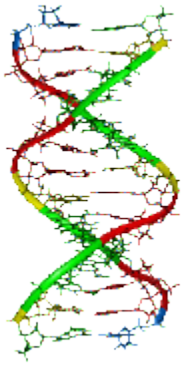
Definition of DNA and Chromosomes

- **DNA** is the basic stuff of inheritance.
- DNA strands are organized into segments called **CHROMOSOMES**. Chromosomes are made up of strings of paired **GENES**.
- Each genetic segment controls a specific effect such as color - or it may influence more than one effect (Example: Frame Overo itself is a color effect resulting from the "Fr" gene, but the gene also causes Lethal White under certain conditions.)
- **Genes come in pairs**, one inherited from Mom and the other inherited from Dad.



This illustration shows a DNA strand breaking apart during meiosis, the form of cell division that creates the egg and sperm for reproduction. Each gene pair separates, with one gene of each pair going into one reproductive cell (egg or sperm) and the other going into another one. So each egg or sperm contains 1/2 the parent's genes - one gene from each pair.

Categories of Genes

- **Dominant** (examples: Gray, Roan) If the dominant gene is present, the horse will be exhibit that trait, regardless of the presence of any other genes) Most color genes are dominant.
- **Recessive** (example: Red.) A recessive gene will only be expressed if it has no other genes to overpower it. Red horses are pure for red. They are incapable of passing on any other color, since it is all they have. (When a red horse produces a foal of a different color, you can be sure that color came from the other parent)
- **Partially Dominant** (example: the Creme gene, which produces palomino and buckskin by partially dominating, or diluting, the red or bay)

In the case of the two Base Colors, red and black, these are both determined at the same place (Latin term "locus" plural "loci") on the DNA strand. This "Locus" is called the Extension Locus, and it is signified by the letter "E". The dominant form, black, is called "E" and the recessive form, red, is "e".

Homozygous & Heterozygous

Genes always come in PAIRS - one from each parent. If both genes are the same (whether recessive or dominant), the animal is called **"homozygous"** for that particular gene. If different, the animal is said to be **"heterozygous"** for that trait.

Because they come in pairs, genetic coding is much like digital coding for computers. Either a gene is "turned on" or "turned off." For an effect to be present, the gene needs to be turned on. This happens if at least one gene in the pair is a dominant gene. (The exception here is the Extension Gene - "turned on" means "black or red" and "turned off" means "red only.")

The only time a recessive gene's action is felt is when it is paired with another just like it (in other words, when it is homozygous). All Red (chestnut, sorrel) horses are homozygous for the recessive Red gene. If they weren't, they would be black, as a single black gene will dominate a red one. Flaxen is the only other known recessive color gene. So flaxen chestnuts are homozygous for both red and flaxen. Thus they always breed true - they have no hidden recessives to pass on to their offspring.

Introduction to Colors

Basic Coat Colors

The basic coat colors of **chestnut, bay, brown and black** horses are controlled by the interaction between two genes: Extension (gene symbol E) and Agouti (gene symbol A). The Extension gene (red factor) controls the production of red and black pigment. Agouti controls the distribution of black pigment either to a points pattern (mane, tail, lower legs, ear rims) or uniformly over the body. The effects of approximately 10 other genes may modify these pigments to provide an array of colors in the domestic horse ranging from white to black.

Dilution

The basic colors can be diluted by at least five genes: **Cream, Champagne, Dun, Pearl and Silver**. The Cream gene has a dosage effect in that a single copy of Cream produces palominos, buckskins and smoky blacks. Two doses of Cream produce cremellos, perlinos and smoky creams. Pearl is recessive; two copies of the gene or one copy of Pearl and one of Cream, are needed to see the dilution effect on the coat color. Champagne, Dun and Silver do not show a dosage effect.

White Patterns

There are several genes responsible for white patterns on horses. White spotting patterns on the base coat color are produced by the Dominant White, Appaloosa, Tobiano and Overo genes or as mixed white and colored hair patterns produced by the Grey (progressive whitening with age) and Roan genes. Several genes are involved in the production of white spotting patterns known as overo. Among those, the gene responsible for the frame-overo pattern is associated with a lethal disease of newborn foals called Lethal White Overo foal syndrome.

Color Definitions

Chestnut (e)

Chestnut (also called sorrel*) is so named because of its gorgeous red-brown shade, just like the fruit of the chestnut tree, actually called the chestnut. Chestnut is a recessive gene and is designated in writing as "e." Geneticists refer to a single e allele as "the red factor." When the horse has two e alleles, then it is homozygous for producing red, aka chestnut. Unless it is bred to a horse with a gene or allele that is dominant over chestnut, then the offspring will always be chestnut.

Black (E)

Black is a dominant gene, which means that when present, it will override the chestnut gene. The designation in writing is "E". A horse can be either homozygous or heterozygous for black. If the horse received an E allele from each parent, it will be homozygous, or EE. If it only received one allele, it is heterozygous, or Ee. Either way, the physical appearance of the horse will always be black because it is dominant.

e	Only the red factor detected. The horse can be assumed to be homozygous for red (ee). The basic color is sorrel or chestnut, but depending on genes at other color loci, the horse could be palomino, red dun, gray, cremello, white or any of these colors with the white hair patterns tobiano, overo, roan or appaloosa.
E/e	Both black and red factors detected. The horse can be assumed to be 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, but depending on genes at other color loci, the horse may be buckskin, zebra dun, grullo, perlino, gray, white or any of these colors with the white hair patterns tobiano, overo, roan or appaloosa.
E	No red factor detected. The horse can be assumed to be 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, but depending on genes at other color loci, the horse may be buckskin, zebra dun, grullo, perlino, gray, white or any of these colors with the white hair patterns tobiano, overo, roan or appaloosa.

Brown

Brown modifies the black gene by creating a lighter brown color in the "soft parts" of the horse. This includes the muzzle, behind the elbow, the belly, and in front of the flank, as well as various other areas on the horse. A genetic marker for brown has not been found yet, so it is not confirmed if it is a dominant gene or not. The overall look of the horse will be a light black or brown. Seal brown is a common description for the color, as is light brown. In some registries, however, brown is not necessarily recognized. Many horse owners will mistake brown for black bay when the horse does not carry the agouti gene to make it a bay. The best way to find out if your horse is brown or black bay is to have it tested for the agouti gene.

White

Horses that appear white may be cremello, gray, perlino, ivory champagne, or an extreme form of one of the appaloosa or pinto patterns, in which the colored areas are so small as to be virtually undetectable.

There also is a true "Dominant White" gene. It is caused by a dominant allele that is probably an embryonic lethal in homozygous form. Scientists haven't located the gene on the DNA of horses yet, but it most likely does exist--some farms are breeding for it now. Please note that, despite common usage of the term, **true "Albino" horses do not exist**, or have never been documented to exist.

Bay

One of the major modifiers of coat colors is the Agouti gene. This is the gene that turns a black horse to bay, which is a brown horse with black legs, mane, and tail, and is quite common. The dominant form is expressed as “A” and a horse that is homozygous for Agouti (AA) will be bay instead of black and will always pass the bay color gene to its offspring. The heterozygous form, “Aa,” will still result in a bay horse but this horse will pass along the dominant Agouti gene only half the time. In the homozygous recessive form, “aa,” a horse will remain black instead of bay. The Agouti gene has no effect on chestnut horses but can be carried in a dominant form (either AA or Aa) by a chestnut horse. This is why we sometimes see bay offspring resulting from a cross of a black horse with a chestnut horse. The black horse gives the dominant base coat color of black , while the modifier, or the Agouti gene, comes from the chestnut parent and makes the resulting offspring bay instead of black.

A/A or A/a	Black pigment distributed in point pattern. The 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	Only recessive allele detected. Black pigment distributed uniformly. The basic color of the horse will be black in the absence of other modifying genes.

Grey(G)

Found in just about any breed, GRAY is a modifier gene that works similar to how a human's hair will turn gray over time. The gray allele, represented in writing as "G," removes the pigment from the horse's hairs over time. The hairs will turn completely white, or the horse will have white hairs with flecks of red or black, known as "flea-bitten gray." However, the horse's skin pigment will not change--the skin will remain dark. As the horse ages, the dark hairs along her buttocks, thighs and gaskins have been replaced with lighter hairs. Dapples have become less prominent, and the mane is showing less black and more gray and white hairs.

There are two key characteristics that define the gray color. First, a gray horse is never born gray. Gray modifies the pigment of the hairs over time, so it is not active when the horse is born. The foal may start showing gray hairs as soon as it start sheading it's foal coat.The second characteristic is that gray is a dominant modifier gene. It will change the color of any horse, whether it's black, chestnut, bay, palomino, or any other color. It does not affect any white markings on a horse, however, as the white hairs are already devoid of pigment. White markings are also accompanied by pink skin, which also will not be affected by the gray gene.

N/G	One copy of the gray gene. Horse will turn gray and approximately 50% of offspring will be gray.
G/G	Two copies of the gray gene. Horse will turn gray and all offspring will be gray.

Roan

The ROAN GENE ("Rn") mixes white hairs evenly throughout the base coat or the main body. True roans usually have normally (non-roaned) colored faces and lower legs. Roan is not progressive -- it doesn't get lighter over the years, as grey does. Roan does, however, change seasonally - being very light, even white, at certain times and dark at others.
True roan is caused by the "Rn" gene, which is dominant. A horse must be a roan in order to have roan offspring. Roan does not "crop out" - at least one parent must be roan.

- Strawberry Roan is the result of the dominant Roan ("Rn") gene modifying Red (sorrel or chestnut).
- BAY ROAN (sometimes also called "Red Roan") results when a BAY base coat is modified by the ROAN gene.

- BLUE ROAN is the ROAN gene on a BLACK base

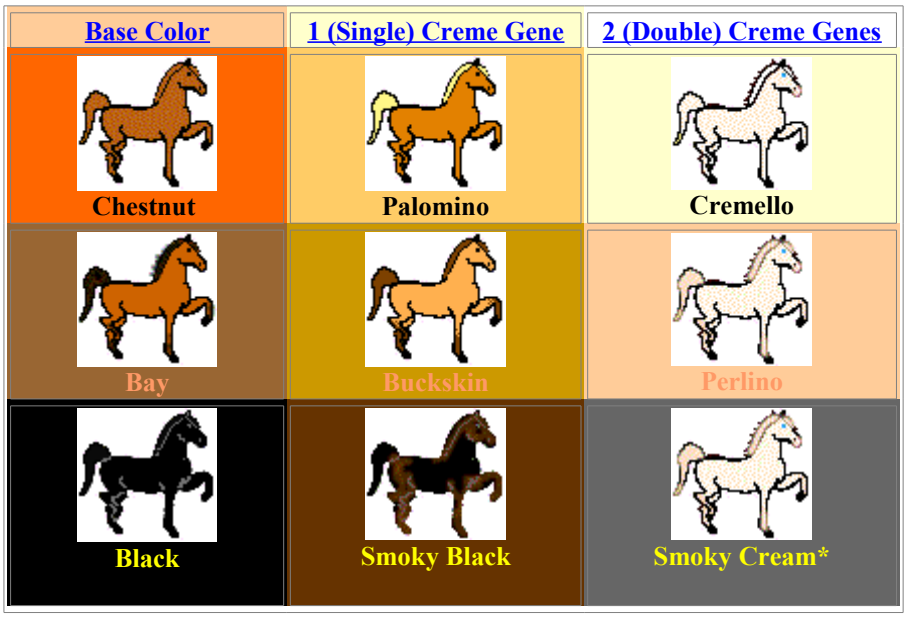
Dilution Definitions

Cream (e)

The Cream dilution gene is responsible for the palomino, buckskin, smoky black, cremello, perlino and smoky cream coat colors. There are two alleles: CCr and C. CCr is semi-dominant and dilutes red to yellow in single dose (palominos, buckskins, smoky blacks) and to pale cream in double dose (cremellos, perlinos, smoky cream). Cream dilution can have a very subtle effect on black pigment. C is recessive and does not dilute the base color.

Cream Dilution results are reported as:

N/Cr	Heterozygous, dilute, one copy of the Cream CCr allele. Chestnut is diluted to palomino; bay is diluted to buckskin and black is diluted to smoky black. These colors can be further modified by the actions of other genes
Cr/Cr	Double dilute (two copies of the CCr allele). Chestnut is diluted to cremello; bay is diluted to perlino and black is diluted to smoky cream.



Champagne

Champagne is a dominant gene that dilutes hair pigment from black to brown and red to gold. Champagne on a chestnut background (Gold) produces a gold body color and often a flaxen mane and tail that can be mistaken for palomino. Champagne on a bay background (Amber) produces a tan body color with brown points. Champagne on a black background (Classic) produces a darker tan body with brown points. The skin of Champagne-diluted horses is pinkish/lavender toned and becomes speckled with age; the speckling is particularly noticeable

around the eye, muzzle, under the tail, udder and sheath. The eye color is blue-green at birth and darkens to amber as the horse ages. Champagne is inherited independently of other coat color genes and thus this dilution can occur in combination with any of the other genes that modify the base colors. Champagne dilution is found in Tennessee Walking Horses, Missouri Fox Trotters, Quarter Horses and related breeds, Miniature Horses and Spanish Mustangs, among others.

Champagne results are reported as:

N/Ch	One copy of the altered sequence detected. Chestnut color (red) is diluted to gold, bay to tan with brown points and black to darker tan with brown points.
Ch/Ch	Two copies of the altered sequence detected. All offspring are expected to be Champagne dilute.

Dun

Dun is a dominant gene that dilutes the color of body hair, leaving the points and head unaffected. Dun horses also show "primitive markings" consisting of a dark dorsal stripe, leg barring, shoulder stripes and concentric marks on the forehead (spiderwebbing, cobwebbing). The dorsal stripe appears to be a consistent feature of dun horses while the other "primitive marks" vary and may not all be present, or visible. The effect of the Dun gene on the base colors of chestnut, bay and black produces horses with shades that range from apricot, golden, dark gray, olive, and many, more subtle, variations. Dun is inherited independently of other coat color genes and can occur in combination with any other genes that modify the base colors. Dun dilution is present in many breeds of horses including Quarter Horses, Paints, Appaloosas, Icelandic Horses, Norwegian Fjords, Paso Finos, Peruvian Pasos and several of the pony breeds. Buckskin is actually created by the cream gene.

The specific mutation that causes Dun has not yet been identified, and there is no direct test for the gene.

Pearl

Horses have four common coat color dilution genes with defined phenotypes: Cream, Dun, Silver and Champagne. Two rare dilution phenotypes have been recognized in Quarter Horses and Spanish horse breeds such as Andalusians and Lusitanos.
In Spanish horses, this dilution is known as **Pearl**. In Quarter Horses and Paints, it has been commonly known as **"Barlink Factor"**.
The two dilutions had long been assumed to be different. Research at the UC Davis Veterinary Genetics Laboratory (VGL) on the Quarter Horses/Paints identified a mutation associated with the "Barlink Factor" dilution. Further research has shown that the same mutation is present in Spanish horses with the Pearl phenotype. The presence of this mutation in Quarter Horses and Paints likely reflects the Spanish horse ancestry of these modern breeds. To recognize that this mutation probably originated in Spanish horses, it is appropriate to name it Pearl.
Pearl behaves as a recessive gene with respect to the hair color. One dose of the mutation does not change the coat color of black, bay or chestnut horses. Two doses on a chestnut background produce a pale, uniform apricot color of body hair, mane and tail. Skin coloration is also pale. Pearl is known to interact with Cream dilution to produce pseudo-double Cream dilute phenotypes including pale skin and blue/green eyes.
Pearl has been identified so far in American Paint and Quarter Horses, Andalusians, Lusitanos, Pasos and Gypsy Horses. Pearl is suspected in American Mustangs from certain herds - notably, High Rock on the California-Nevada border - that produce horses with a unique "metallic" look to their coats.

N/Prl	One copy of the altered sequence detected. If Cream dilution is also present, a pseudo-double Cream phenotype will result.
Prl/Prl	Two copies of the altered sequence detected. On a chestnut base color, a uniform apricot color of body hair, mane and tail will result.

Silver

The horse Silver dilution gene dilutes black pigment but has no effect on red pigment. The mane and tail are lightened to flaxen or silver gray, and may darken on some horses as they age. A solid black horse with this gene will be chocolate colored with a lightened mane and tail. A bay horse will have the black pigment on the lower legs, mane and tail lightened. Sometimes bay horses with Silver dilution can be mistaken for chestnuts with a flaxen mane and tail. Silver dilution is inherited as a dominant trait. It is known to occur in Rocky Mountain horses and related breeds, Shetland ponies, Icelandic and Morgan horses.

N/Z	One copy of the altered sequence detected. Black-based horses will be chocolate with flaxen mane and tail. Bay-based horses will have pigment on lower legs lightened and flaxen mane and tail. No effect on chestnut color.
Z/Z	Two copies of altered sequence detected. Black-based horses will be chocolate with flaxen mane and tail. Bay-based horses will have pigment on lower legs lightened and flaxen mane and tail. No effect on chestnut color.

White Spotting Patterns

Appaloosa

The entire range of Appaloosa patterning is called the "Lp" ("Leopard") complex of genes. Appaloosa genetics are complicated and not yet fully understood. More than one gene may be at work in creating the wide range of appaloosa patterns.
Current research indicates that Appaloosa patterns are not caused by a single gene. We refer to the "Leopard complex", or Lp, as the group of genes that must be responsible for appaloosa patterns, but we don't know what all the genes are or how they work. We know that the leopard appaloosa pattern appears to be dominantly inherited, but we know nothing about the other patterns.
Appaloosa Traits:

- Spotted Skin (This trait is necessary, and common to all appaloosas, regardless of hair color)
- Striped Hooves (except occasionally in horses with white socks)
- Sclera (white of the eye) showing
- Eyes may be any color, from light blue through hazel through dark brown

Appaloosa Coat Patterns:

- Leopard – Large spots all over (dark spots on a light base coat)
- Snowflake: Large spots all over (light spots on a dark base coat)
- Blanket: White on hips and loins with or without spots
- Marble: Small dark sprinkles on a light base coat
- Frost: Small light sprinkles on a dark base coat

Tobiano

Tobiano spotting is a pattern of white hair with underlying pink skin which can occur with any other coat color, and can occur in combination with other patterns. The pattern is present at birth and stable throughout life.
Tobiano is a coat pattern that is single gene dominant - in other words - a horse needs only to inherit a single Tobiano gene from one parent in order to show the pattern. If the horse carries the gene, it will show it.
Whether the horse carries one (heterozygous) or two (homozygous) Tobiano genes, the pattern will manifest itself. Tobianos who carry two Tobiano genes (homozygous) may show visual clues, which include "cat track" spotting, "ink spots" etc., but if you want to know for sure, get the horse tested. Homozygous breeding stock is desirable to breeders, as their offspring will always be Tobiano.
Tobiano Traits:

- head markings like those of a solid-colored horse; their heads may be completely solid, or have a blaze, strip, star or snip. (Extreme facial white, such as Aprons, bald faces, etc. are NOT Tobiano traits.)
- Generally, all four legs are white, at least below the hocks and knees.
- **White** extends **over the topline; (the reverse of Frame Overo)**
- The tail is usually white at the base, and black or red at the tip.

Overo

The OVERO group of pinto/paint patterns includes three distinct genetic agents (although the visual effects are not always so distinct, and often a horse may carry more than one pattern, hence they are all lumped together as "Overo") - basically if it isn't Tobiano, it's Overo, but the underlying genetics are variable. Also in this group is "TOVERO" - which is any white pattern that is not clearly Tobiano, or which may include characteristics of both Tobiano and Overo patterns.

Frame Overo

The Frame Overo pattern is so-called because the base body color seems to "frame" the white patterning. This pattern occurs almost exclusively within horses descended from the original Spanish horses.

- White patches are FRAMED by body color
- OVERO = BODY COLOR lies OVER the topline
- Frame Overo carries with it the risk of Overo Lethal White Syndrome

Sabino

Sabino is a generic description for a group of similar white spotting patterns. The sabino pattern is described as irregular spotting usually on the legs, belly and face, often with extensive roaning. A mutation has recently been discovered that produces one type of sabino pattern. It has been named Sabino1 as it is not present in all sabino-patterned horses. More mutations will probably be identified that account for other sabino patterns.
Sabino1 is inherited as an autosomal dominant mutation. One copy of the Sabino1 gene is expected to produce horses with two or more white legs or feet -- often with white running up the anterior part of the leg, an extensive blaze, spotting on the midsection, with jagged or roaned margins to the pattern. Horses with 2 copies of the Sabino1 gene, are at least 90% white and are referred to as Sabino-white.

Sabino1 is most commonly found in Tennessee Walking Horses. Other breeds in which this mutation has been found include: American Miniature Horses, American Paint Horses, Aztecas, Missouri Foxtrotters, Shetland Ponies, Spanish Mustangs and Pony of the Americas. Other breeds of horses that are known to have sabino patterns, such as Clydesdales and Arabians, have so far tested negative for the Sabino1 mutation, although the number of animals tested is low.
Sabino 1 results are reported as:

N/SB1	One copy of the Sabino1 gene detected. Horse typically may have 2 or more white legs, blaze, spots or roaning in the midsection and jagged margins around white areas.
SB1/SB1	Two copies of the Sabino1 gene detected. Complete or nearly complete white phenotype expected.

Though lumped in with other overo patterns for registration purposes, Sabino is different genetically, and is not connected with Overo Lethal White Syndrome. Current research indicates Sabino is polygenic - that is, controlled by more than one gene. These interact in ways not yet fully understood to create the wide range of sabino expression. Sabino also commonly occurs in combination with other patterns, especially the other Overo patterns (Frame and Splash).
Sabino four basic subtypes:

- Sabino characteristics – tall jagged stockings, chin spot larger blaze (no matter the size or number of these items on one horse)
- Moderate sabino – White blotches of ticking (rount) under belly, under chin, bald face, hind stockings running up to top line (no matter the size or number of these items on one horse) sort of an expansion on characteristics type markings
- Full Sabino Pinto – horse has body white the is unmistakable a pinto pattern of more than 25% white (jagged white patches not ticking, large irregular pattern running up from entirely white belly, white legs, white under side of neck (sort of a reverse war shield), white sides)
- Maximum White sabino – a white horse with dark eyes (occasionally 1 or 2 light blue eyes due to markings that are covered over by the sabino white) May be born with slight coloring in ears, mane and tail – this color generally fades within the first year.

Splashed White

Splashed White shares a number of characteristics with the other Overo patterns, including ample facial white, white lower legs, and body white that starts on the belly and extends upward. It can sometimes resemble Tobiano as well, but is usually more of a reverse Tobiano pattern, with color over the topline and white below.
"Splash white, in it's **minimal** form, tends to include a blaze (the blaze will often have more white on the nose than on the forehead-this is often called a "**bottom heavy**" blaze) and **some white on the feet**. It's unknown exactly how minimal splash can get...

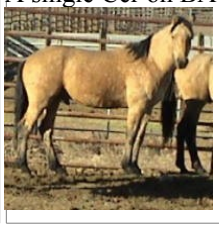
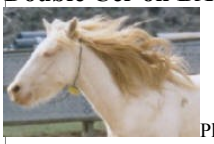
- A **splash white pinto** typically has **four white legs**, a lot of **white on the face**, and often has a **two toned tail** (the white tends to be on the ends of the tail hairs).
- The **body white starts on the belly**, and seems to **work its way straight up the body, in jagged shapes with smooth, not lacy, edges.**
- The effect of a splash white pinto is likened to the horse being, literally, dunked into a vat of white paint.
- Splash can be very extensive, up to and including putting white on the ears. **It can be as extreme as an all white horse**, with only color on the ears. I don't know of any totally white horses *known* to only have the splash gene, although totally white horses may have the splash gene *in addition* to another pinto gene or two...

Tovero

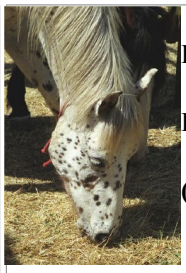
Tovero is a term used for color patterns that appear to be a cross or blending of Tobiano and any of the Overo family of patterns. This is entirely possible genetically, since all of the pinto genes are dominant. Traits include:

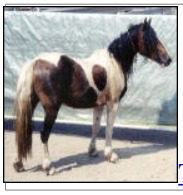
- Dark pigmentation around the ears, which may expand to cover the forehead and/or eyes.
- One or both eyes blue.
- Dark pigmentation around the mouth, which may extend up the sides of the face and form spots.
- Chest spot(s) in varying sizes. These may also extend up the neck.
- Flank spot(s) ranging in size. These are often accompanied by smaller spots that extend forward across the barrel, and up over the loin.
- Spots, varying in size, at the base of the tail.

Appendix A: Genetic Color Notations

COMMON GENETIC NOTATION		
Gene	**Name & What it does**	**Result**
A	Agouti (Bay Modifier): Acts on "E" to restrict eumelanin to points; No effect on "e" or red	 Bay
C	Non-dilute	**Full Color**
Ccr	Creme: Dilutes phaeomelanin markedly, eumelanin a little **A single Ccr** on RED = **Palomino**  A single Ccr on BLACK = **Smoky Black**  A single Ccr on BAY=**Buckskin** 	**Double Ccr** dilutes the single creme colors even further: **Double Ccr on Red = Cremello**  **Double Ccr on Black = Smokey Cream** **Double Ccr on BAY = Perlino**  Photo: Andi Harmon; perlino mustang adopted by Greg Schultz
Ch	Champagne: A dilution gene that creates pumpkin-colored freckled skin, amber eyes, and unique bronze cast to hair coat	 Champagne Champagne gene on Red =**Gold** Champagne on Bay = **Amber** Champagne on Black =**Classic** Champagne + Creme = **Ivory**

D	 **Dun** dilution - dilutes both eumelanin and phaeomelanin	Dun on Red = Red Dun Dun on Bay = Dun, Zebra Dun, Bay Dun, Classic Dun Dun on Black = Grulla/o
d	Non-dilute	**Full Color**
Ed, E+	**Dominant black**, epistatic to A locus	**Black**
E	Dominant form of "Extension" locus; Allows either **eumelanin (black pigment) or pheomelanin (red pigment)** * (normal notation)	**Black,** unless other gene, such as A modifies  Ranger from Coyote Lakes and his adopter, Karen
e	Recessive form of "extension" locus; Allows Phaeomelanin (**red pigment**)only; epistatic to A locus	 **Red (chestnut, sorrel)**
F	Red points on ee horses	**Tostado or alazan**
f	Flaxen points on ee horses (This is Sponenberg notation)	**Ruano**
Fr	 photo: Ginny Freeman **Frame Overo** "Fr" is not the commonly accepted genetic symbol for frame overo. "O" is used in all scientific publications. Sponenberg uses the Fr symbol, but no one uses it. So a frame overo is Oo, and solids are oo.	**Frame Overo** **Also: Overo Lethal White Syndrome**

G	 **Grey -** gradually covers and replaces any other color; eventually becomes white with dark skin	 Dave Howe & Deserito **Grey**
Lp	 Photo: Terry Crawford **Leopard** **(NOT a single gene!)**	 Ajax, owned by Edona Miller **Appaloosa Complex:** leopard, snowflake, varnish roan, blanket, etc.
O	**(Frame) Overo** 	Overo for registration purposes includes a variety of color patterns, but the genetic symbol, O, for Overo, refers to Frame Overo only.
P	 **Pangare ("Mealy")** light golden areas over muzzle, eyes, elbow and flank	 right photo by Judy Goulet **"Belgian"Sorrel, Seal Brown, or "WILD DONKEY" Bay**
Rb	 **Rabicano** photo courtesy of arabianrun.com	**Rabicano**
Rn	**Roan** 	**Roan**

Sb	 **Sabino**	 **Sabino**
Spl	 photo by Marlene Maki **Splashed White**	**Splash, Splashed White**
Sty	**Sooty/Smutty** - black mixed into body coat	 **Sooty**
To	**Tobiano**	 **Tobiano**
W	**White** 	**Dominant White** Pink skin, blue or brown eyes
Z	 *Karma, Cold Springs HMA Mustang adopted by Andi Harmon of*	**Converts black to brown with white mane and tail**

	Oregon **Silver dapple** - dilutes eumelanin only	

Horse Coat Color Table

	Chestnut C eeaa	Chestnut C eeAa	Chestnut C eeAA	Black K Eeaa	Bay or Brown B/N EeAa	Bay or Brown B/N EeAA	Black K EEaa	Bay or Brown B/N EEAa	Bay or Brown B/N EEAA
Chestnut C eeaa	100% C	100% C	100% C	50% K 50% C	25% B/N 25% K 50% C	50% B/N 50% C	100% K	50% B/N 50% K	100% B/N
Chestnut C eeAa	100% C	100% C	100% C	25% B/N 25% K 50% C	37.5% B/N 12.5% K 50% C	50% B/N 50% C	50% B/N 50% K	75% B/N 25% K	100% B/N
Chestnut C eeAA	100% C	100% C	100% C	50% B/N 50% C	50% B/N 50% C	50% B/N 50% C	100% B/N	100% B/N	100% B/N
Black K Eeaa	50% K 50% C	25% B/N 25% K 50% C	50% B/N 50% C	75% K 25% C	37.5% B/N 37.5% K 25% C	75% B/N 25% C	100% K	50% B/N 50% K	100% B/N
Bay or Brown B/N EeAa	25% B/N 25% K 50% C	37.5% B/N 12.5% K 50% C	50% B/N 50% C	37.5% B/N 37.5% K 25% C	56% B/N 19% K 25% C	75% B/N 25% C	50% B/N 50% K	75% B/N 25% K	100% B/N
Bay or Brown B/N EeAA	50% B/N 50% C	50% B/N 50% C	50% B/N 50% C	75% B/N 25% C	75% B/N 25% C	75% B/N 25% C	100% B/N	100% B/N	100% B/N
Black K EEaa	100% K	50% B/N 50% K	100% B/N	100% K	50% B/N 50% K	100% B/N	100% K	50% B/N 50% K	100% B/N
Bay or Brown B/N EEAa	50% B/N 50% K	75% B/N 25% K	100% B/N	50% B/N 50% K	75% B/N 25% K	100% B/N	50% B/N 50% K	75% B/N 25% K	100% B/N
Bay or Brown B/N EEAA	100% B/N	100% B/N	100% B/N	100% B/N	100% B/N	100% B/N	100% B/N	100% B/N	100% B/N