

## All About Color FAQs

### How many different color genes do Aussies have?

Dogs have at least 10 major canine coat color genes and an unknown number of minor ones. Genes for the following have been located:

- Black/liver – tyrosinase related protein 1 (TYRP1) on chromosome 11
- Merle – Silver (Silv) on chromosome 10
- Sable/tan trim – agouti signal peptide (ASIP) on chromosome 24
- “Dominant black”/brindle – beta-defensin 103 (CBD103) on chromosome 16
- Dilution – melanophilan (MLPH) on chromosome 25
- Mask/yellow – melanocortin receptor 1 (MC1r) on chromosome 5
- Harlequin – protease beta subunit type 7 (PSMB7) on chromosome 9

The other major genes are:

- White markings (there actually at least two and probably more of these)
- Chinchilla (lightens tan/sable/yellow pigment)
- Ticking
- Graying

We don't see Graying (as in Kerry Blue terriers), harlequin (as in Great Danes), sable and brindle, so those are apparently fixed with double copies of gene versions that do not produce the color or pattern in Aussies. (What is referred to as “harlequin” in Aussies is not the same pattern nor due to the same gene.) People often mistakenly call yellow dogs (which may actually be anywhere from pale yellow to deep red-gold in color) “sable” but sable is due to a dominant version of ASIP. Since the color is unacceptable in Aussies and has been since at least the mid-1970s the gene version that causes it is extremely unlikely to remain in our breed's gene pool.

Dilute and yellow are unacceptable colors caused by recessive gene versions so we see them occasionally. The same is true for Chinchilla (pale tan markings) because we select away from it. Therefore most Aussies have two gene versions that do not express these colors. Thus far (2013) one major white marking gene has been identified, microphthalmia-associated transcription factor (MITF) on chromosome 20, has been found in the Boxer. There is at least one more associated with the type of white markings seen in collie-type dogs like the Aussie. Other species, like mice, have multiple “spotting” genes, so it is very likely dogs do, too. Note: the word “microphthalmia” in the name of the gene does not mean this is the cause of microphthalmia in Aussies. The name was originally given to a mouse gene where there is a connection. In Aussies microphthalmia is found in double merles.

**Most common colors:**



Self Black



Black Tricolor



Black Bicolor



Black & Tan



Self Blue Merle



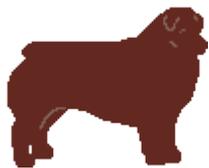
Bleu Merle White & Tan



Bleu Merle White



Bleu Merle & Tan



Self Red



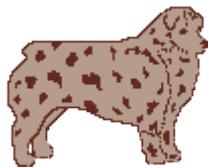
Red Tricolor



Red Bicolor



Red & Tan



Self Red Merle



Red Merle White & Tan



Red Merle White



Red Merle & Tan

## The outcome in breeding

R = red factored

X	Blue-Merle	Blue-Merle/R	Black-Tri	Black-Tri/R	Red-Tri	Red-Merle
Blue Merle	Not allowed	Not allowed	Blue-Merle, Black-Tri	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R	Blue-Merle/R, Black-Tri/R	Not allowed
Blue-Merle/R	Not allowed	Not allowed	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R, Red-Tri, Red-Merle	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R, Red-Tri, Red-Merle	Not allowed
Black-Tri	Blue-Merle, Black-Tri	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R	Black-Tri	Black-Tri, Black-Tri/R	Black-Tri/R	Blue-Merle/R, Black-Tri/R
Black-Tri/R	Blue-Merle, Blue-Merle/R, Black-Tri, Black-Tri/R	Blue-Merle/R, Black-Tri, Black-Tri/R, Red-Tri, Red-Merle	Black-Tri, Black-Tri/R	Black-Tri, Black-Tri/R, Red-Tri	Black-Tri/R, Red-Tri	Blue-Merle/R, Black-Tri/R, Red-Tri, Red-Merle
Red-Tri	Blue-Merle/R, Black-Tri/R	Blue-Merle/R, Black-Tri/R, Red-Tri, Red-Merle	Black-Tri/R	Black-Tri/R, Red-Tri	Red-Tri	Red-Tri, Red-Merle
Red-Merle	Not allowed	Not allowed	Blue-Merle/R, Black-Tri/R	Blue-Merle/R, Black-Tri/R, Red-Tri, Red-Merle	Red-Tri, Red-Merle	Not allowed

## What non-standard colors are most common in Aussies?

Too much white most common, with dilute next closely followed by yellow. Yellow and dilute are both recessive, so they have continued to lurk in the breed gene pool, showing up only when two carriers happen to be bred to each other. The basic “irish” pattern of white markings typical of Aussies is probably caused by a single gene but modified one way or the other by additional genes or regulatory DNA.

## Were Aussie colors the same as they are now in the early years?

For the most part, with a marked preference for blue merle. But many years ago, before the current standards were set, there were all sorts of colors and patterns in Aussies: Piebalds, brindles, sables, and saddle-patterns (like a German Shepherd Dog or Airedale,) as well as yellows and dilutes. The precursor of all the breed standards we use today was established in the late 1970s, establishing black or liver, with or without merle patterning and with or without white and/or tan trim as acceptable colors for the breed. Since then breeders have been selecting away from all the other colors and patterns. Some are gone entirely, but those that are recessive linger.

### **What color-associated health issues occur in Aussies?**

Dogs that have two copies of the merle gene virtually always have abnormally developed eyes which frequently are blind. They may also be deaf due to lack of pigment in the inner ear.

White markings on or around the ears are associated with deafness due to lack of pigment in the inner ear, the same mechanism as deafness in double merles but with a different genetic cause.

Areas of white marking typically cover pink skin. If the skin is exposed (eye rims, lips, nose) or sparsely covered with hair (sometimes the top and end of the muzzle) there is risk of UV sun damage if the dog spends a lot of time in intense sunlight.

Dilute, a disqualifying color that sometimes occurs in the breed, is associated with skin problems in some breeds. However, this does not appear to be a consistent problem in dilute Aussies.

Blue eyes are not more susceptible to eye defects and disease but they are more sensitive to bright light (as they are in blue-eyed people.) There is no clear association of blue eyes to deafness in Aussies, deaf Aussies virtually always have too much white or are double merle.

### **How are blue eyes inherited?**

In merles blue eyes are an extension of the merle patterning. Just as the coat has variegated pigment, so can the eyes.

Blue eyes in non-merle Aussies can vary in appearance. Sometimes one eye is blue, sometimes both. They may be completely blue, or perhaps half blue/half pigmented. They are never marbled but may have smaller blue segments. Small flecks of blue in a non-merle may arise by chance, just as they do in human eyes.

Blue eye not related to merle are sound, though perhaps light sensitive. Siberian Huskies are an example of another breed with this type of blue eye. The mode of inheritance is unknown, but since the blue eyes can be single or a pair and an individual eye may be half-and-half, there is probably more than one gene involved. This type of blue eye probably occurs in merles, too, but there is no way to distinguish them from eyes that are blue due to a single copy of the merle gene.

### **It's OK for Aussies have eyes that are brown or blue; are amber or yellow eyes acceptable?**

In Aussies they are, in some other breeds they are not. The Aussie standard allows amber. Some other breeds' standards specify that it is only allowed with some coat colors and others allow only brown or even dark brown. (A few demand dark brown with all colors even though some colors cannot have dark brown eyes because eye pigment will be lightened by the genes that cause certain colors.) Eye color is cosmetic and should never be a make-or-break decision point on the quality of a dog.

### **What gene causes black color?**

Tyrosinase-related protein 1 (TYRP1) which has been called "B" by dog breeders for decades.

**Does B (TYRP1) cause other colors?**

Yes. It is also the cause of liver (also called brown, chocolate or red). NOTE: Colors referred to as “red” in other breeds (Irish Setters, Australian Cattle dogs, and others) are not due to B but are caused by other genes.

**How many versions does B (TYRP1) have?**

Four. The most dominant causes black. The other three all cause liver and for practical purposes are treated as a single version. It is possible different shades of liver might be caused by the three recessive versions but that has yet to be determined.

**Are the B (TYRP1) colors acceptable in Aussies?**

Yes, they are the two basic body colors in the breed.

**How are the B (TYRP1) colors inherited?**

Black is dominant and red is recessive. A dog needs only one copy of the dominant version of B to be black. Those with one copy of a recessive version are “red factored” or “red carriers” and can produce red puppies if bred to a dog that also has at least one copy. A dog cannot be liver unless it has two recessive versions of B.

**My dog is a dark red bi but his nose is black, so what color is he?**

It’s impossible to say without seeing the dog, but his color may be a result of the most recessive allele at the “E” locus. Homozygotes (those with two copies of the “e” version of the gene) will be anywhere from a pale yellow to a deep chestnut. Yellow Labradors are ee. So are Golden Retrievers and Irish Setters. They look different due to modifying genes that determine the depth of pigment. Your dog might be ee. If so, he inherited that version of the gene from both of his parents.

**How come some dogs are red but have black noses?**

Because the dog isn’t “red” (liver) but gets its reddish color from another gene, most likely the yellow version of “E” which can be a deep red-gold or, in the case of an Irish setter, deep red.

**What gene causes the merle pattern?**

Silver (SILV), which has been called “M” by dog breeders for decades.

**Does M (Silv) cause other patterns or colors?**

No, however dogs which inherit two copies of the merle version of the gene will have more white (in Aussies usually much more white) than dogs with one or no merle version of the gene. The pigmented areas of the coat are generally lighter in color than typical of their near kin. The “double merles” will also have developmental eye defects which in Aussies are generally severe and may be deaf if there is extensive white on the head.

**How many versions does M (Silv) have?**

Three, the most dominant is merle, next is cryptic, and most recessive is non-merle

### **Is the M (Silv) pattern acceptable in Aussies?**

Yes. It is a signature of the breed. Though non-merles are allowed in the public eye merle = Aussie.

### **How is the M (Silv) pattern inherited?**

- A dog with two copies of the merle version is a “double merle.”
- A dog with one copy of the merle version plus either cryptic or non-merle will be a normal merle.
- A dog with two copies of cryptic or one cryptic and one non-merle will be a cryptic merle (mostly solid color with one or a few very small patches of merle, with or without white or tan).
- A dog with two copies of non-merle will not be merle.

### **If harlequin merle Aussies aren't harlequin, what are they?**

The scientific community calls the gene for this Aussie merle variation “Tweed” or Tw for short. The gene was given this name to avoid confusion with the Harlequin pattern in Great Danes and because the first choice “splotch, had already been applied to a mouse color. Tw causes a multi-shade merle pattern, usually with three or four shades in moderate sized splotches on a pale background. The blue merle version is generally easy to spot. Red merles are sometimes less so. It is recessive so a dog that has the tweed pattern will pass the gene to all of its offspring. Non-merles can carry tweed, but since they aren't merle, you can't tell from looking at them whether they have it or not.

### **Is it true that horses have a “lethal white” gene just like Aussies, Collies, and Shelties?**

No. What the dogs have is merle, caused by the gene called SILV. Having two copies of the dominant version of the gene usually results in dogs that are blind and/or deaf and often are mostly white. However it does not kill the dog. Horses have a mutation in an entirely different gene called ENDRB. It gives horses the overo color pattern. When a foal inherits two copies of the overo mutation it is always lethal.

### **My veterinary ophthalmologist said my black dog had eyes that look merle inside. Is my dog a cryptic merle?**

There is a particular appearance to the tapetum (reflecting pigment) in the eyes of merle dogs. The pigment variation we see outside the dog in the coat and irises also occurs in other pigmented tissue like the tapetum and this was probably what the vet was referring to. However, I would be skeptical of attempts to designate a dog a “phantom” (cryptic) merle solely on the basis of tapetal pigment.

### **Are black or liver dogs that have irregular white spots on the ears or body cryptic merles?**

If the hair is actually white, no. The small merle spots seen in cryptic merles will be colored (blue or light liver.) If there is doubt, examine the hair under a microscope; pigmented hair will have visible pigment. No pigment visible means the hair is white and the dog is a mismark.

### **Are black or liver dogs that have puppies with too much white cryptic merles?**

No.

### **Why is the merle gene sometimes lethal?**

It isn't. The myth arose from some very early research that indicated that there might be very serious health issues other than with the eyes and ears in dogs that inherit two copies of the merle gene; this has proven not to be the case.

### **What goes wrong with double merles?**

The merle gene causes changes in cells that arise in melanocytes (pigment cells) during development. Pigment cells occur in the eyes and inner ear, as well as in the skin and hair follicles. Merle causes a reduction of pigment. If a dog has only one copy of the merle gene, it will have the merle color pattern, leaving some areas with full color (black or liver) while other areas are a lighter shade. If the dog has two copies of the gene, some cells will have no pigment at all, which leads to deafness when they are located in the inner ear, or will develop abnormally, as happens in various tissues within the eye. The defects in the ears and eyes can result in deafness or blindness.

### **Will double merles have health problems other than being blind or deaf?**

The only health issue other than those of the eyes and ears is a risk for sun damage to pink areas of skin if the dog spends a lot of time in sunlight. Some very early studies of double merles indicated that they might have or develop a wide range of health issues, however there is no definitive research supporting those early suppositions and anecdotal evidence from owners of double merle Aussies does not support it, either.

### **What kind of eye defects do double merles have?**

Dogs that inherit two copies of the merle gene ("double merles"), usually have multiple eye defects, generally with associated vision loss which often goes to the point of blindness. Any part of the eye can be affected. Irises are frequently deformed, sometimes grossly so. Pupils may be subluxated (off-center). The lens may be subluxated (out of place). The retina may be abnormal, and the optic nerve may be improperly developed. The entire globe of the eye may be abnormally small (microphthalmia). Most double merles will have one or combination of these defects in each eye. All of this can be avoided by not breeding merle dogs to each other.

### **Are eye problems common in Aussies because we have so much merle?**

Dogs with two copies of the merle gene usually have multiple and significant problems with the eyes. Dogs with only one or no merle genes will not have the eye problems typical of a double merle.

Aussies do have a number of eye problems, but these are independently inherited. Even though some of these bear some resemblance to the problems seen in double merles, they are genetically distinct. Puppies who have only one merle parent and normal merles from two merle parents are no more likely to have eye problems than any other dog.

### **Are dogs out of many generations of merle to merle breeding more likely to have or produce eye problems?**

No. The number of generations of merle to merle breeding has no bearing on whether or not a dog will have or carry eye problems. Except for the problems that occur in double merles, the fact a dog is merle is only a coincidence if it happens to have other eye diseases. The only

exception is iris coloboma, which is much more frequent in merles but still occurs in non-merles, too.

**Does breeding merle-to-merle increase the possibility of deafness in the breed?**

Only in the puppies that inherit two copies of the merle gene. This can be avoided by not breeding merles to each other.

**I have a mismarked merle puppy which has two white ears. Will this puppy be deaf?**

Not every dog with white ears has a hearing problem, whether it is merle or not. But there isn't any way to predict just from appearance whether it can hear. The problem isn't confined to Aussies and isn't necessarily related to merle. Deafness associated with white markings on the head is common in a number of breeds. The white is just an indicator that pigment may be lacking in the inner ear and the white ear may not be the deaf one

If there is a lack of pigment inside the ear, the dog will have some degree of hearing loss. This may be slight or profound. White on or around the ears—whatever the gene that put it there—indicates a possibility of lack of pigment inside, too.

**Is it safer to breed two blue merles together than two red merles?**

The problem with merles isn't whether they are blue or red but in the breeding of *any* two merles to each other.

**If a cryptic merle is bred to a regular merle, will there be eye and ear problems?**

The gene version that causes cryptic merles – dogs that look like non-merles except for a small patch of merle – apparently has does not cause the issues associated with double merles, even when bred to a merle. You may breed them the same way you would if the dog were a non-merle.

**What causes tan trim?**

Agouti signal peptide (ASIP), which has been called “A” by dog breeders for decades.

**Does A (ASIP) cause other colors or markings?**

Yes, sable, wolf grey, and “recessive black” – actually a lack of tan trim on a black or liver dog.

**How many versions does A (ASIP) have?**

Yes. In order of dominance: Sable, wolf grey, tan point, and recessive black.

**Are the A (ASIP) colors and markings acceptable in Aussies?**

Aussies may have tan trim or not. Neither sable nor wolf grey are acceptable.

**How are the A (ASIP) colors inherited?**

- A dog with two sable versions or one sable plus any of the other versions will be sable.
- A dog with two wolf grey versions or one wolf grey plus a tan point or recessive black will be wolf grey.
- A dog with two tan point versions or one tan point and one recessive black will have tan points.

- A dog with two recessive black versions will not have tan trim.

**Is there another gene that causes tan trim not to appear on a black or liver dog?**

Yes. Beta-defensin 103 (CBD103), referred to as “dominant black” by dog breeders for decades, or more recently as “K.” (Like “recessive black” this is a dog without tan points which has either a black or liver coat color.)

**Does K (CBD103) cause any other colors?**

No colors, however it does cause the brindle pattern in some dogs.

**How many versions does K (CBD103) have?**

Three: dominant black, brindle, tan points possible.

**Are the colors, markings and patterns caused by K (CBD103) acceptable in Aussies?**

Aussies may have tan trim or not. The brindle pattern is not acceptable.

**How are the colors and patterns caused by K (CBD103) inherited?**

- A dog with two dominant black versions will not have tan points; actual color will depend on the action of other genes.
- A dog with two brindle versions or a brindle and a tan trim possible will be brindle IF it is also yellow or yellow with a black mask. Color of the branding will depend on the actions of other genes.
- A dog with two tan trim possible versions may have tan trim if the dog has the proper versions of A to have tan trim.

**What gene causes white markings color?**

There are at least two major and an unknown number of minor genes that -determine white markings. One of the major ones is not present in Aussies.

**Do the white marking genes cause other colors?**

No. They block pigment from forming so whatever color the hair might have been is white instead.

**Are white markings acceptable in Aussies?**

They are not required, but are acceptable within certain limits. Aussies may have a white muzzle, white on the throat and chest, a blaze that may extend into the collar, a collar, white on the underbody, white legs below the elbow and hock, and white on the tip of the tail. White markings elsewhere are considered mismarks.

**How are white markings inherited?**

The details are still murky, but having no or minimal white is dominant to lots of white. White markings have a continuum from a tiny bit on the chest or toes to a dog that is completely white. Dogs with acceptable markings who have puppies with too much white are carrying genes for the extra white and should be bred to mates from families where excess white does not occur.

My dog is solid color and had a normal puppy coat but now that he has his adult coat it has individual white hairs scattered through. Is this faulty?

This occurs occasionally and there is no clear understanding of whether it is inherited. It is arguable whether it is a clear violation of the standard but it certainly isn't typical. It is only cosmetic so treat it as a minor fault.

**Are there different genes for white markings on different parts of the body (head, collar, leg, etc.)?**

Probably, though it hasn't been studied. There may be genes that influence where white shows up or regulatory DNA that switches those genes on or off. To a small extent the shape of a white marking may be influenced by chance or environment (cloned animals of other species that have white markings will vary slightly even though they are essentially identical twins). Particular variations (half-white heads for example) do run in families. Some breeds, like the Bernese Mountain Dog, have been selected for very uniform white markings.

**Have mismarked Aussies become more frequent than they were years ago?**

Possibly, though it is difficult to know for sure. Very early in In breed history dogs with what we would now consider too much white were not unusual. However, once the precursor to today's standards was created in the late 1970s the distribution of white markings became fairly well-defined. The limitations were included to discourage people from keeping double merles but applied to all colors. For the most part, people stopped breeding the mismarked dogs and breeders generally culled them.

The show ring gives preference to dogs with white markings and exhibitors like to have as much white as possible and therefore show breeders have been selecting toward the limits for white. Inevitably some puppies will have too much. Some working and performance breeders are not overly concerned by cosmetic faults and therefore may breed a mismarked dog to preserve its qualities. Finally, there has been an ethical shift in attitudes toward culling: Breeders are far less likely today to cull a puppy because of a cosmetic fault. All of these could contribute to a real or apparent increase in frequency for mismarks.

**Does T cause other colors?**

It only causes ticking, though that can vary from a few spots on An Aussie's muzzle or legs to the relatively large and uniform spots of a Dalmatian to the densely ticked roan observed Australian Cattle dogs, some Coonhounds and other breeds.

**How many versions does T have?**

Two: Ticking and no ticking, with ticking being dominant. The variations in size and distribution of the ticking spots are governed by modifying genes or regulatory DNA.

**Is ticking acceptable in Aussies?**

The breed standards don't specifically address it, but a small amount of ticking is generally accepted. Preferences run toward less rather than more.

**What determines the color of ticking spots?**

Ticking will be whatever color that part of the dog would have been if it didn't have white markings.

**How is ticking inherited?**

Dogs with one or two copies of the ticking version will be ticked though the amount will vary. Dogs with two copies of the no ticking version will not be ticked.

**What gene causes dilution?**

Melanophilan (MLPH), called “D” by dog breeders for decades.

**Does D (MLPH) also cause dilution spots?**

No. Dilution spots, grey and often rusty or dull areas in a merle pattern, are related specifically to merle with the genetic cause unknown at this time. D dilutes all black or liver pigment, including the lighter areas in a merle coat.

**Does D (MLPH) cause other colors?**

While D causes a dramatic lessening of pigment there are other things that also affected density of pigment. The colors produced by D may vary somewhat depending on whatever other factors may be in play. For example, in liver Aussies the color can run from a deep chocolate to an orangey-red. This variation might make some dilutes, especially red merle dilutes, difficult to distinguish from a non-dilute but less densely pigmented dog

**How many versions does D (MLPH) have?**

Two non-dilute and dilute, with dilute being recessive.

**Is dilute acceptable in Aussies?**

No.

**How is dilute inherited?**

It is recessive. A dog with two non-dilute versions of D will not be dilute nor can it produce dilute. A dog with one non-dilute and one dilute version will carry dilute. Dogs with two dilute versions are dilute.

**Is this the only type of Dilute in Aussies?**

No. The researcher who identified melanophilan dilute in Aussies also received samples from dilute dogs that did not have this mutation. Therefore there are other ways dilute may be inherited though they likely are recessive. Sometimes Aussie puppies will be born dilute but as they mature their coats darken until they can't be distinguished from normally colored Aussies. This is not typical of melanophilan dilute, which is the same from birth onward.

**What gene causes yellow color?**

Melanocortin receptor 1 (MC1r), long called “E” by dog breeders.

**Does E (MC1r) cause other colors or patterns?**

Yes. It causes facial masks and the grizzle pattern in Salukis (called “domino” in Afghan Hounds.)

**How many versions does E (MC1r) have?**

Four: Mask, grizzle, black (actually whatever color other genes determine), and yellow in that order of dominance.

**Are the E (MC1r) colors and patterns acceptable in Aussies?**

“Black” is acceptable and mask only affects tan pigment so might reduce or eliminate tan points on the face. Grizzle doesn't occur in Aussies but wouldn't be acceptable if it did and

yellow is not acceptable. Since yellow can obscure merle patterning to the point you cannot tell the dog is merle it isn't a color that would be advisable in Aussies. E does not interfere with white markings.

### **How are the E (MC1r) colors inherited?**

Dogs with two copies of the mask version, or one copy of mask and any of the other versions will have a mask with the rest of the dog (save any white areas) will be yellow to reddish or possibly sable (depending on the versions of A it has.) Dogs with two copies of the grizzle version or one copy plus a copy of the black or yellow versions will be grizzle. A dog with two copies of the black version or one black and one yellow will be whatever color other genes determine. A dog with two copies of the yellow version will be yellow, though actual shade can range from pale yellow to deep red-gold. Yellow Aussies are usually a medium-gold shade.

### **What determines nose color in yellow dogs?**

The B and D genes. The nose will be black or liver depending on what versions of B the dog has. If the dog also has two recessive copies of D the nose may be slate blue or a pale, even pinkish, brown.

### **What do people mean when they say a dog's nose is "Dudley" or "butterfly?"**

A dudley nose is one with no pigment at all (i.e. pink.) This is very unusual in Aussies but will sometimes be seen in homozygous merles. "Butterfly" refers to a nose that has an unpigmented (pink) area across the front. The term probably arose because these pink patches sometimes are vaguely butterfly-shaped.

Unpigmented areas on the nose are undesirable because they are more subject to sun damage than a pigmented nose would be. In addition, unpigmented noses can be less acute at scenting—though even a dudley-nosed dog has a far better sense of smell than any human.