TinyBear Pomeranians

POMERANIAN SPECIFIC COAT PATTERN GENETICS

Known and testable unless otherwise stated.

Dominant genes, represented by capital letters, require only one copy (heterozygous) to be active. Recessive genes, represented in the lower case, require two copies (homozygous) to be active. There is an order of dominance among the recessives. With the exception of Agouti, the dominant allele is written as a capital letter.

Dominant and Recessive genes:

A - Locus	Dominant:	(a^y)	sable (fawn).
	Recessive:	(a^w)	wolf sable (wild type).
		(a^t)	tan point pattern (black and tan, blue and tan, brown and tan etc.)
		(a)	recessive black

Note: A is known as Agouti. This is the order of dominance: (a^y) is dominant to (a^w), (a^t) and (a). (a^w) is dominant to (a^t) and (a). (a^t) is dominant to (a). For a complete explanation of Agouti see: please see here: http://www.tinybearpoms.com/Agouti%20Pattern%20Gene--final.pdf

B - Locus	Dominant:	B	black coat and points (lips, nose, eye rims, and paw pads)
	Recessive:	b	brown coat and points when in homozygous form only (b/b)

B/B is a black phenotype and the dog can only pass B to its puppies.
B/b is a black phenotype but the dog can pass either B or b to its puppies.
b/b is a brown phenotype and the dog can only pass b to its puppies.

Since B/B and B/b express the same black phenotype. Instead of writing B/B and B/b, we write B/x. The x can mean either B or b.

D - Locus	Dominant:	D	non dilute.
	Recessive:	d	dilute when in homozygous form only (d/d).

D/D is NO dilution in phenotype and the dog can only pass D to its puppies.
D/d is NO dilution in phenotype but the dog can pass either D or d to its puppies.
d/d is Diluted phenotype and the dog can only pass d to its puppies.

Since D/D and D/d express the same non-dilute phenotype. Instead of writing D/D and D/d, we write D/x. The x can mean either D or d.

E - Locus	Dominant:	E^M	produces a melanistic mask.
		E	allows for the expression of eumelanin (black or brown).
	Recessive	e	prohibits all production of eumelanin in homozygous form only (e/e).

E/E is NOT clear red/orange/cream. It allows eumelanin (black or brown) production. The coat is controlled by K and/or A (agouti). The dog can only pass E to its puppies.

E/e is NOT clear red/orange/cream. It allows eumelanin (black or brown) production. The coat is controlled by K and/or A (agouti). The dog can pass either E or e to its puppies.

E/Em is NOT clear red/orange/cream. The coat is controlled by Agouti and has a melanistic mask. It allows eumelanin (black or brown) production and always creates a melanistic mask. The dog can pass either E or Em to its puppies.
Em/Em is NOT a clear/red/orange/cream. It allows eumelanin (black or brown) production and creates a melanistic mask. The dog has a mask and will pass this dominant mask gene to its puppies.

e/e is a pheomelanin phenotype ONLY. The dog is red/orange/cream with NO black or brown (including whiskers) and can only pass e to its puppies. e/e overrides K and A (agouti).

Since E/E and E/e both express eumelanin without a mask. Instead of writing E/E and E/e, we write E/x. The x can mean either E or e but not E^M.

The gene known as the E locus is the Melanocortin Receptor 1 gene (MC1R), formerly called the Melanocyte Stimulating Hormone Receptor Gene (MSHr). The MC1R gene has been mapped to dog chromosome 5. This gene has two common alleles E and e. Dogs that are e/e are red/orange/cream due to phaeomelanin production, and this is the recessive genotype. These dogs shouldn't have any black or brown hairs on them including whiskers and eye lashes. This does not affect nose colour as e/e dogs can have black, brown or diluted black or brown noses. When E is present in a dog, it usually has some black or brown in its coat including black or brown whiskers and eye lashes because of the production of eumelanin. The E allele is dominant to the e allele.

Although the e/e genotype is the most recessive at this locus, it overrides other genotypes at other loci, such as the K and A locus.

E^M is the top dominant allele in this series. The mutation causing mask has recently been found in the MC1R allele and is offered as a test by Healthgene.

The mechanism by which a black mask is formed is an interaction between the E gene with the agouti protein and melanocyte (pigment producing cells) stimulating hormone. The E^M allele allows agouti to bind some of the time and cause fawn (sable) pigment to be made on the body and the melanocyte stimulating hormone to bind on the face instead. Because of this any phaeomelanin pigmented dog (i.e. yellow, fawn (sable), red, cream) with a mask, must be so colored due to an agouti genotype. Such dogs cannot be "e/e" at MC1R because an E^M allele is required for the production of a melanistic mask. Since it is inherited as a dominant trait, a dog with a mask could be either heterozygous or homozygous for E^M . The extent of the mask or depths of colour do not seem to be affected by the number of copies of E^M. Melanin pigment can be black, blue, brown or diluted brown and therefore the term "melanistic" mask includes all these types of masks.

Although some dogs classified as white, Samoyed and some German Shepherd Dogs, test e/e, we have white pomeranians who tested E/e suggesting another gene may be involved in creating white.

K – Locus	Dominant	K^B	solid colour (does not mean that no white markings occur)
	Recessive	k^{br}	brindle pattern, dominant to (k^y) and allows for the expression of Agouti.
		k^y	allows for the expression of Agouti.

K^B K^B solid Eumelanin (black or brown) phenotype and the dog can only pass Kb to its offspring.
K^B k^{br} solid Eumelanin (black or brown) phenotype and the dog can pass either K^B or k^{br} to its offspring.
K^B k^y solid Eumelanin (black or brown) phenotype and the dog can pass either K^B or k^y to its offspring.
$k^{br}k^{br}$ allows A locus to express (sable, wolf sable, tan point) with brindling.
k^{br} k^y allows A locus to express (sable, wolf sable, tan point) with brindling.
k^y k^y allows expression of agouti patterns without brindling.
k^{br}/k^{br} or k^{br}/k^y and a^y/x, the brindling is over all of the coat.
k^{br}/k^{br} or k^{br}/k^y and a^t/a^t or at a^t/a, brindling is only in the regions of tan of the tan point patterned coat.

In some breeds, the K Locus is 'fixed' as homozygous for K^B. Some of those 'fixed' breeds depend on the E Locus to determine if a dog will be clear red/orange/cream/(yellow) or allow the B Locus (black or brown) to be expressed. Yet in other 'fixed' breeds the B Locus determines black or brown alone. The Pomeranian is not 'Fixed' as homozygous for K^B. Pomeranians are solid black, brown, or diluted black or brown when d/d is present, if they have one copy of K^B but can be tested for homozygosity. Both the brindle mutation $k^{br,}$ and the k^y alleles are recessive to K^B. Distinguishing these two recessive alleles with a "simple" DNA test is not yet possible since the brindle mutation is a complex mutation.

The Brindle allele is on the K Locus so it is on a different chromosome than the E locus. Brindle is dominant to sable so only one copy of k^{br} is required. However the dog must also have either an E or E^m allele as discussed below. Likewise since k^{br} is recessive to K^B, no K^B allele can be present in the dog. Therefore all brindle dogs are either k^{br}/k^{br} or k^{br}/k^y.

To have a brindle phenotype, a dog must have one E^m, in which case it will be a brindle with a melanistic mask; or one E allele, in which case it will be brindle with no mask. Dogs that are "e/e" have a dysfunctional melanocortin 1 receptor and are unable to make black hairs anywhere on their body. This means that a dog with an "e/e" genotype could carry brindle and it would not be expressed.

If the k^{br} allele is present in a sable dog with a black mask, it would be expressed. Brindle can be carried and not expressed by a sable or and clear red/orange/cream - "e/e". However, most sable dogs with no mask that show shading from the dorsal to ventral side of their body are E/E, a^y/a^y and since E allows the expression of brindle, such dogs could not be hidden carriers of brindle either.

The E^M allele allows agouti to bind some of the time and cause fawn pigment to be made on the body and the melanocyte stimulating hormone to bind on the face instead. Because of this any phaeomelanin pigmented dog (i.e. yellow, fawn, red, cream) with a mask, must be so colored due to an agouti genotype. Such dogs cannot be "e/e" at MC1R because an E^m allele is required for the production of a melanistic mask.

Occasionally one hears of two sable or clear red/orange/cream dogs having brindle pups. This is possible if one is of "e/e" genotype (the brindle carrier) and the other has at least one E or E^m allele.

S – Locus	Dominant:	S	non-spotting
	Recessive	s^p	spotting

In some dogs, a white chest spot occurs. Some standards mention this as a fault. This is likely simply incomplete pigment migration in the particular individual, and not an inherited trait. Such small amounts of white on the chest or on the toes do not seem to be caused by mutations in MITF.

The genetic determination of white spotting in dogs is complex. In breeds such as Collie, Great Dane, Italian Greyhound, Shetland Sheepdog, Boxer and Bull Terrier, piebald behaves as a dosage-dependent trait. A dog with one copy of the MITF variant has some white pattern expression, while a dog with 2 copies of the variant display more extreme white with color only on the head and perhaps a body spot. In Boxers and Bull Terriers, dogs with 2 copies of the MITF variant are completely white and dogs with 1 copy display the mantle (called flash in these breeds) pattern. However, additional mutations in MITF or other white-spotting genes appear to be present in these breeds that affect the amount of white being expressed. In other breeds, piebald behaves as a recessive trait- that is 2 copies of piebald are needed to produce white spotting. The Pomeranian is not specifically mentioned in these test results. We have white Pomeranians which only carry one copy of s^p, suggesting that their white coat is caused by some other gene.

Chart of Genotypes: (as much as can be proven through testing)

We use 'x' to denote either capital or small case letter as it doesn't matter to the sequence.

Solid Black	B/x E/x D/x K^b / (K^b or k^x)
Solid dilute black (Blue)	B/x E/x d/d K^b / (K^b or k^x)
Solid Brown	b/b E/x D/x K^b / (K^b or k^x)
Solid dilute brown	b/b E/x d/d K^b / (K^b or k^x)

The APC officially refers to dilute brown as beaver. Some people and other Standards call dilute brown: lavender, lilac, Isabella etc. No matter the name, they are all dilute brown although the intensity of the actual colour can vary as intensity genes have been postulated.

Clear red/orange/cream	e/e - this overrides anything at K or A (agouti)
With black points add	B/x D/x
With blue points add	B/x d/d
With brown points add	b/b D/x
With beaver points add	b/b d/d

Red/orange/cream sable	E/x k^y/k^y a^y/x
With black points add	B/x D/x – tips are black
With blue points add	B/x d/d – tips are blue
With brown points add	b/b D/x – tips are brown
With beaver points add	b/b d/d – tips are beaver (remember some call it beaver while other

say lavender, lilac, Isabella etc)

Tan point pattern	E/x k^y/k^y a^t/a^t or a^t/a (because of order of dominance at Agouti) k^y
allows Agouti to be expressed	
As black and tan add	B/x D/x
As blue and tan add	B/x d/d
As brown and tan add	b/b D/x
As Beaver and tan add	b/b d/d

When the 'tan marking are brindled' change k^y/k^y to k^{br}/x (x denotes both k^{br} or k^y)

Brindle Pattern	E/x k^{br}/k^x (k^{br} allows Agouti to be expressed)
Black points and coat add	B/x D/x
Blue points and coat add	B/x d/d
Brown points and coat add	b/b D/x
Beaver points and coat add	b/b d/d