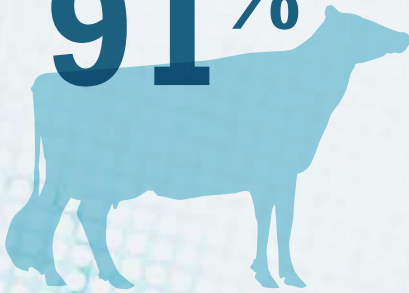




GENETICS 101

COAT COLOUR

91%



Approximate percentage of Holsteins that have the E^D E^D gene combination (seen as black) at the Recessive Red location of the genome.

E^{BR} & E^+

Due to current testing limitations, both are often reported as E^+ . Holstein Canada consults pedigree to determine whether E^{BR} or E^+ is the likely gene and codes the registered animal accordingly.

We hope to unravel some of the confusion surrounding coat colour in the Holstein breed. Over the past decades, coat colour is becoming better understood thanks in part to lineage records and genomic research. Research in this field is ongoing. There are two gene locations responsible for coat colour (the Dominant Red location and Recessive Red location). We'll start with the more familiar Recessive Red location.

1. RECESSIVE RED GENE LOCATION

This is where the genes for Black (E^D), Black/Red (E^{BR}), Wild-type red (E^+), and True Red or Recessive Red (e), and are located. These 4 genes are listed in order of dominance in the table below. Each animal has two coat colour genes in this location: one from its sire and one contributed by its dam. Therefore, the most dominant gene will be the one expressed in the animal's phenotype (outward appearance). An animal with the $E^D e$ combination will show black though their genotype carries the Recessive Red gene (indicated as B&W *RDC on a pedigree). It is important to note that not all genomic tests are currently able to differentiate between E^{BR} and E^+ , so the E^+ code is often used for both. As a result, care must be taken because animals labelled as $E^+ e$ and $E^+ E^+$ may exhibit as black/red or as red.

Order of Dominance for genes at the Recessive Red location

GENE	NAME	PHENOTYPE
E^D	Dominant/Black	Black
E^{BR}	Black/Red	Black/Red
E^+	Wild-type	Red
e	Recessive/True red	Red

2. DOMINANT RED GENE LOCATION

There is a second, lesser known, gene location that can affect coat colour. It is very uncommon for these genes to override the expression of the coat colour genes at the Recessive Red location because less than 1% of the Holstein population has a Dominant Red gene found at this second location. Over 99% of Holsteins have the genotype $d d$, in which case the genotype from the Recessive Red location gets expressed.

For animals with a homozygous ($D D$) OR heterozygous ($D d$) Variant Red genotype, they will have red coat colour. This remains true even if they have homozygous black ($E^D E^D$) genes at the Recessive Red location of their DNA. The Variant Red gene (D) dominates over any other coat colour genes that the animal has.

Order of Dominance for genes at the Dominant Red location		
GENE	NAME	PHENOTYPE
D	Dominant/Variant Red	Red
d	Black	Black

When registering an animal, there are validation processes that take place to ensure the code colour being recorded is plausible. However, animals already recorded in the herdbook don't automatically get reviewed. Calves born red that change to black/red (B/R from the E^{BR} gene) can easily be recorded improperly as $R\&W$ due to that colour change and the fact that many coat colour tests don't distinguish between the black/red gene (E^{BR}) and the wild-type gene (E^+) that can produce a true red calf.

If you come across animals that seem to have the wrong coat colour indicated on their pedigrees, please contact Customer Service (customerservice@holstein.ca or 1-855-756-8300 x410).

Homozygous

Meaning "of the same". Animals with a homozygous genotype have received the same gene for a specific trait from both sire and dam (example: $e e$ is homozygous Recessive Red).

Heterozygous

Animals with a heterozygous genotype for a trait have received a different gene from the sire and the dam. Whichever gene is most dominant is the gene that will be expressed in the phenotype. (example: $D d$ is heterozygous Dominant Red).

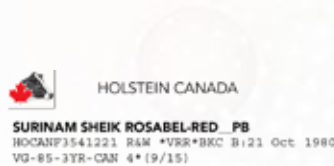


COAT COLOUR: A History of Names

Throughout the years, many coat colour genes have been given multiple names, some of them tracing back to specific families.

- E^{BR}** : Black/Red, "Telstar gene." Roybrook Telstar has been identified as the originator of the gene. A couple black/red carrier (*BRC) bulls from more recent history are Storm and Baxter.
- e** : Recessive Red, True Red, Red Factor
- D** : Dominant Red, Variant Red, Mutant gene, the "Rosabel Effect"

The gene traces back to the red (phenotype) Canadian cow Surinam Sheik Rosabel-Red who was sired by a black E^D E^D bull. Her pedigree indicates R&W



*VRR *BKC. This is translated as red and white coat colour, due to the dominant Variant Red gene, though she is a carrier of the black gene (E^D) also.

Islehaven Champions Mutant was red and white due to the Variant Red gene, though he had to be heterozygous (D d) because he had both R&W and B&W progeny. At the recessive red gene location, he carries the black and recessive red genes (E^D e).

If he was bred to a black red, red carrier cow with the genotype d d, E^{BR} e, the following demonstrates the possible genetic and phenotypic outcomes.



Genotype outcomes at the Dominant Red location

		Sire (D d, E ^D e)	
		D	d
Dam (d d, E ^{BR} e)	d	D d	d d
	e	D d	d d

Genotype outcomes at the Recessive Red location

		Sire (D d, E ^D e)	
		E ^D	e
Dam (d d, E ^{BR} e)	E ^{BR}	E ^D E ^{BR}	E ^{BR} e
	e	E ^D e	e e

Outcomes								
Dominant Red gene location	50% D d Red Coat Colour is dominant over the Recessive Red location genotype				50% d d Coat colour determined by the Recessive Red location denotype			
	Recessive Red gene location	E ^D E ^{BR}	E ^D e	E ^{BR} e	e e	E ^D E ^{BR}	E ^D e	E ^{BR} e
Each of these outcomes have a 12.5% chance of happening from the above mating	R&W	R&W	R&W	R&W	B&W	B&W	B/R	R&W
	*VRR	*VRR	*VRR	*VRR	*BRC	*RDC	*RDC	*RDC
	*BKC	*BKC	*BRC	*RDC				
	*BRC	*RDC	*RDC					