

Designer Cattle

An Introduction to Basic Bovine Genetics

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Skill Level: Intermediate

Time Required: 45 Minutes

Cost: \$10

Supplies: Red and black coloring utensils, quarters, activity sheets

Introduction:

This lesson will focus on introducing basic traits used in the selection of beef cattle as well as how they are determined by genetics.

Introduction to Methodology:

The activity will open by asking students to define genetics and discussing answers. A short visual presentation accompanying this lesson may be presented and discussed. Students will then use their understanding of genetic concepts to complete four cattle pictures from information provided in a handout. Next, students will select two animals to breed and use provided information as well as a quarter to "design a calf." Students will then be asked to explain the role of genetics in the appearance of cattle.

Learning Outcomes:

Students will be able to...

- Define genetics and its importance in beef production
- Explain basic genetic terms and vocabulary
- List at least three traits of interest in beef cattle
- Determine a phenotype when provided a genotype

Success Indicator:

Students will be successful if they...

- Correctly correlate genotypes with their associated phenotypes
- Utilize proper terminology in describing their calf

Educational Standards Supported:

This lesson is designed to encourage additional learning to compliment club and group activities. It is not intended to align with any Tennessee Department of Education Standards.

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Suggested Opening Question:

Begin by asking students if they are familiar with the term "genetics" and to briefly define it. Spend a few minutes sharing and discussing answers. If using the accompanying presentation, reveal the correct definition. Then ask students why genetics are important in beef production and discuss their answers. Correct answers can be revealed from the presentation.

Introduction of Material:

Once students have become familiar with the concept of genetics as well as its importance, use a few minutes to introduce the different terms and vocabulary used in genetics. Explain key concepts such as dominant allele, recessive allele, etc. Explain how to determine phenotypes (observable characteristics) based off of genotype (the genetic makeup). Then introduce a few traits of interest found in beef cattle. The presentation provides these definitions and explanations.

Activity:

Once students are familiar with the basic concepts and simple traits, briefly explain that they will now have the opportunity to look at the genotype of four animals to determine their phenotypes. This will be done using the "Build Your Herd" activity sheet provided in this packet. Students will use the table on this sheet to color the animals. Once students have finished, ask them to share what their cattle look like. Spend a few minutes discussing the correct answers, which are provided in this packet and in the presentation.

After finishing your discussion of "Build Your Herd," explain to the students that they will now be able to "design a calf." Explain that alleles from two parents are passed down at random, so they will flip a quarter to randomly determine the genotype of their calf for multiple traits. Provide students with a few minutes to complete this activity and color their calf.

Wrap Up & Outcome:

Ask students to share their calves and one new fact that they learned. Ask students to name one way in which genetics can help in beef production and discuss. Finally, ask for any remaining questions.

For a more detailed walk-through explanation, please see "Visual Presentation Explained."

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Visual Presentation Explained

Slide 1: Designer cattle opening slide

Begin by introducing the activity and what you hope students will learn.

Slide 2: What is genetics?

Use this time to pose the question of "What is genetics?" Give students the opportunity to have an open discussion while you direct the conversation and provide guidance.

Slide 3: Genetics definition

Explain to students that genetics is the study of how certain qualities and traits are passed from parent to offspring through DNA when two animals are bred together.

Slide 4: Why is genetics important?

Now that students are familiar with the term genetics, ask them "Why is genetics important?" Allow students to have an open conversation while providing guided direction. Discuss their answers.

Slide 5: Genetics helps us too

Provide students with some additional answers, such as to make breeding decisions, cull animals, and increase efficiency.

Slide 6: Key vocabulary

Tell students "Before we can fully understand how genetics works, we have to familiarize ourselves with some basic vocabulary!"

Slide 7: Genome

Begin introducing the vocabulary by starting broad. Start by explaining that the genome is all of the genetic material of an organism. This information is stored in DNA and located on chromosomes. The genome includes all chromosomes, and each organism has two copies (one from each parent).

Slide 8: Chromosome

Start by introducing the chromosome as the structure which contains genetic information stored in DNA.

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Visual Presentation Explained (continued)

Slide 9: *Gene*

Then explain that a gene is the smallest unit of inheritance that controls a trait. Genes are located on chromosomes and passed down from parent to offspring. For example, basic coat color is controlled by a gene.

Slide 10: *Allele*

Explain that an allele is a variant of a gene. Make the connection between a gene and an allele by referencing the coat color example for gene on the previous slide. An example of an allele in this case is that one variant results in a black coat color while another variant results in a red coat color.

Slide 11: *Dominant*

Open the conversation about the types of alleles by starting with an explanation of dominant alleles. These are alleles that will mask the phenotype of other alleles in the heterozygous state. If an allele is dominant, it will be visible or measurable even if another allele is present. These are represented by uppercase letters.

Slide 12: *Recessive*

Move on to discuss recessive alleles next. These are alleles whose phenotypes are masked in the heterozygous state. If a dominant allele is present, then the phenotype associated with the dominant allele will be seen. Recessive alleles are represented by lowercase letters.

Slide 13: *Genotype*

Using the students' new knowledge of genes and alleles, move on to a discussion of genotype. This is the genetic makeup of an organism for a specific trait or gene. This is represented by the upper and lowercase letters associated with dominant and recessive alleles.

Slide 14: *Phenotype*

Once students understand genotypes, lead the discussion of phenotypes by explaining that an animal's genotype determines their phenotype.

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Visual Presentation Explained (continued)

Slide 15: *Homozygous*

Next, turn to a discussion of the different genotypes possible. A homozygous genotype is when an individual has two of the same alleles for a specific gene. Both letters of this animal's genotype will be the same case (both uppercase or both lowercase).

Slide 16: *Heterozygous*

Explain next that a heterozygous genotype is when an individual has two different alleles for the same gene. These individuals will have both an uppercase and lowercase letter. In the case of simple dominance, these individuals will display the phenotype of the dominant allele. In the case of incomplete dominance, these individuals will have an intermediate phenotype (i.e., incomplete dominance in flowers: dominant red + recessive white = intermediate pink).

Slide 17: *How does it work?*

While it is great to have the scientific understanding of genetics, student must be able to apply the information to real life, so take this opportunity to ask students if they understand how genetics works.



Slide 18: *Selection*

Take time to explain that the first step in genetics is selection. This is the important process in which a producer chooses which bull and cow to breed together. These decisions are based on performance and genetic data. Explain to students that we want to improve the genetic value of our cattle, so it is important to make strong selection choices.

Slide 19: *Breeding*

Next, explain that a bull and cow are bred together, and in this process the sperm and oocyte containing the bull and cow's genetic information combine. This results in a calf with around 50 percent DNA from both the bull and cow.

Slide 20: *The molecular level*

Finally explain to students how this 50/50 share of DNA occurs by explaining that calves inherit one copy of each chromosome from both parents (one from the bull and one from the cow).

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Visual Presentation Explained (continued)

Slide 21: Traits of interest

Moving forward, tell the students "We will now take this new knowledge and look at a few traits of interest in beef cattle!"

Slide 22: Sex

The first trait of interest is biological sex. Explain to students that this is a chromosome dependent trait. There is a gene on the Y chromosome, known as SRY (due to its location in the sex-determining region of the Y chromosome), which is responsible for sex determination. Explain to students that if a Y chromosome is present, then the individual is male. In the event that a Y chromosome is not present, the individual is female (XX).

Slide 23: Chromosome images

The next slide provides images of sex chromosomes. Take a moment to ask students if they can spot the size difference between the X and Y chromosomes.

Slide 24: Sex examples

The next slide provides examples of the different phenotypes which result from the XY (male) genotype and XX (female) genotype.

Slide 25: Hide appearance

The next slide provides a variety of examples for hide appearance. Use this time as an opportunity to introduce all the ways in which hides can vary, such as coat color and white markings.

Slide 26: Coat color

First introduce the most basic trait that affects hide appearance: coat color. This is a simple inheritance trait. Explain that black is the dominant phenotype and is represented by an uppercase B. Red is the recessive color and is represented by a lowercase b. The homozygous dominant and heterozygous genotypes both result in a black coat color. The homozygous recessive genotype results in a red coat color.

Slide 27: Coat color examples

Provided on this slide are examples of the different phenotypes for the coat color gene.

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Visual Presentation Explained (continued)

Slide 28: How do you get white or other light colors?

Next, show students the photo on slide 27 and ask students "How do you think we get the white coat when black and red are the only alleles for coat colors?"

Slide 29: Diluter

Explain to students that the white coat color and other light coat colors are a result of the diluter gene. This gene operates under incomplete dominance, meaning that there are three possible phenotypes. Dilution is dominant and represented by an uppercase D. A homozygous dominant individual will be white regardless of what is present at the coat color gene (i.e., a cow is BB for the coat color gene but DD for the diluter gene so the cow is white). A heterozygous individual will be a diluted or light version on whatever coat color is present from the coat color gene (i.e., a cow is BB for the coat color gene but Dd for the diluter gene so the cow is diluted black or almost gray in color). A homozygous recessive individual will display full color based on what is present for the coat color gene (i.e., a cow is BB for the coat color gene and dd for the diluter gene so the cow is full black).

Slide 30: Diluted colors

Walk students through the possible phenotypes that result from the diluter gene: white, diluted black, and diluted red.

Slide 31: What about the face, stockings, underline, and tail?

Next pose the question "How do you think we get the white face, stockings, underline, and tail?" to the students. Have an open discussion and encourage their engagement.

Slide 32: White markings explained

Use the graphic provided on this slide to explain what white markings are controlled by the white marking gene. These include the face, underline, stockings, and tail (may also be referred to as the extremities). Be sure to explain the difference between a white face and a blaze face. A white face and blaze face are not the same and are not controlled by the same gene.

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Visual Presentation Explained (continued)

Slide 33: White markings

Move forward and explain that the gene for white markings is controlled by simple inheritance. The dominant allele is for white markings and is represented by an uppercase F. The recessive allele is for no white markings and is represented by a lowercase f. Homozygous dominant and heterozygous individuals will display white markings. Homozygous recessive individuals will not display white markings.

Slide 34: White markings examples

Show students the examples of white markings that result from having either the homozygous dominant or heterozygous genotypes.

Slide 35: Horns or no horns

Next, show students the example pictures for polled versus non-polled animals, and take time to discuss that polled refers to animals who do not have horns or scurs (incompletely developed horns).

Slide 36: Polled/horned

Explain to students that the presence or lack of horns is a simply inherited trait in which the polled phenotype is dominant. This is represented by an uppercase P. The presence of horns is recessive and represented by a lowercase p. Homozygous dominant and heterozygous individuals are polled while homozygous recessive individuals have horns.

Slide 37: Polled/horned examples

Then show students the example of polled cattle versus horned cattle.

Bonus learning point

Discuss with students how both phenotypes can be present within one breed.

Slide 38: Now determine their phenotypes!

Introduce students to today's learning activity, "Build Your Herd," and explain that they will be determining each animal's phenotype based on the genotypes in the chart on their print out. Ask students to color each animal and give them some time to work. Then ask students to describe how their cattle appear.

Slide 39: Traits of interest guide

If a projector or screen is available, you may display this slide to aid students in the activity.

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Visual Presentation Explained (continued)

Slide 40-43: Eugene-Edna

Once students have shared how their cattle appear. Take a few moments to reveal the correct answers from the visual presentation. An answer key can also be found in this packet. Ask students if their cattle appear the same as the ones on the screen and provide explanations and guidance as necessary.

Bonus learning point
Discuss with students how breed affects genotype and phenotype. Ask students to identify the breeds of these cattle. You may also discuss crossbreeding.

Slide 44: Now design your own calf

After all students have completed "Build Your Herd," move forward to the second part of the activity: "Create a Calf." Explain to students that they will select one of the two bulls and one of the two cows from the "Build Your Herd" activity to breed together. Students should circle the bull and cow's name on their worksheet. Student will then flip a quarter to determine which allele should be used for each gene for each animal. Next, they will determine the phenotype of their calf from this information and color the picture on the handout. A detailed guide and explanation of this activity is provided in this packet. Provide students with a few minutes to complete their calves.

Slide 45: Traits of interest guide II

Slide 46: How do they look?

After all students have completed their calves, begin asking students to share. It will be helpful if students share both the genotype and phenotype as this will provide an opportunity to ensure thorough understanding of the subject.

Slide 47: What did you learn?

Now give students the opportunity to share what they learned. You may prompt them with questions, such as "What is a genotype," "What is the phenotype for a cow that is BB for coat color and dd for diluter," or "What is the difference between a gene and an allele."

Slide 48: Questions?

Provide a final opportunity to pose any questions or ask for clarification.

Slide 49: Thank you!

Conclude the presentation and consider sharing contact information if appropriate.

Vocabulary



Genome

All of the genetic material of an organism stored in DNA and found on chromosomes. Consists of a copy of each chromosome from each parent



Chromosome

Structure which contains genetic information in the form of DNA



Gene

Smallest unit of inheritance located on a chromosome and passed down from parent to offspring



Allele

A variant of a gene that results in a specific phenotype



Dominant

An allele that expresses itself even in the heterozygous condition



Recessive

An allele that does not express itself in the heterozygous state



Genotype

The genetic makeup of an organism for a specific trait



Phenotype

An observable characteristic that results from an organism's genotype



Homozygous

When the two alleles at a gene are the same



Heterozygous

When the two alleles at a gene are different



Simple dominance

Heterozygous organisms display the dominant phenotype



Incomplete dominance

Heterozygous organisms display intermediate phenotype

Traits of Interest



Hide appearance

Diluter

Dominant: Dilute (D)

Recessive: Full color (d)

DD: White

Dd: Diluted color

dd: Full color

White markings

Dominant: White (F)

Recessive: Solid (f)

FF: White

Ff: White

ff: Solid

Coat color

Dominant: Black (B)

Recessive: Red (b)

BB: Black

Bb: Black

bb: Red

Sex

Dominant: Male (Y)

Recessive: Female (X)

XY: Male

XX: Female

Polled/horned

Dominant: Polled (P)

Recessive: Horned (p)

PP: Polled

Pp: Polled

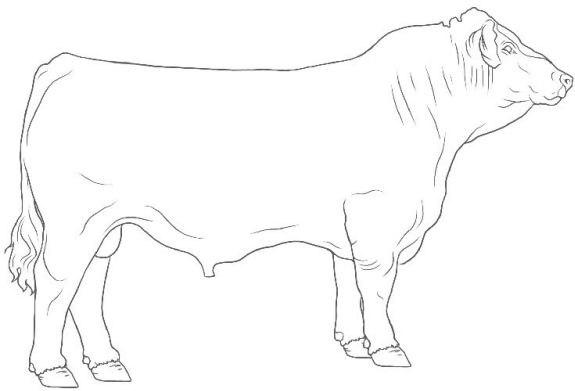
pp: Horned

Build Your Herd

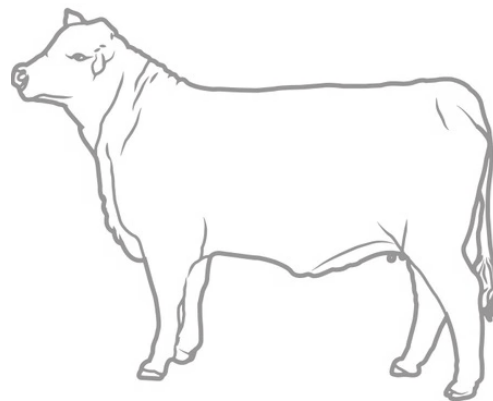
Directions:

Using the chart below and your knowledge about dominant and recessive alleles in beef cattle, color the four animals as their genotype says their phenotype will appear.

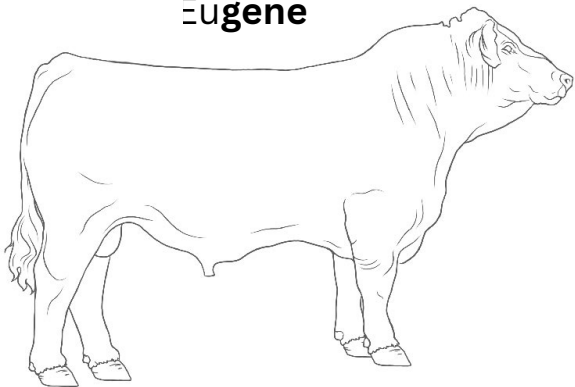
	Eugene	Dominic	Geneva	Edna
Sex	XY	XY	XX	XX
Coat color	Bb	bb	bb	BB
Dilution	dd	DD	dd	dd
W. Markings	FF	ff	FF	ff
Horns	Pp	Pp	pp	PP



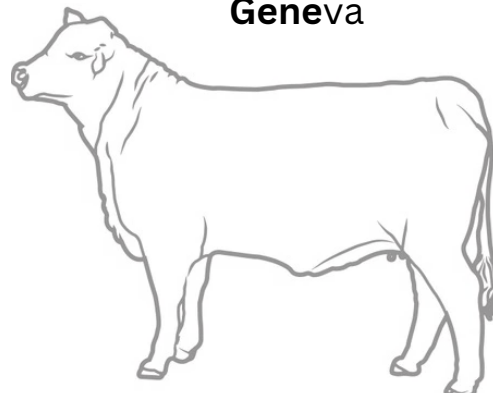
Eugene



Geneva



Dominic



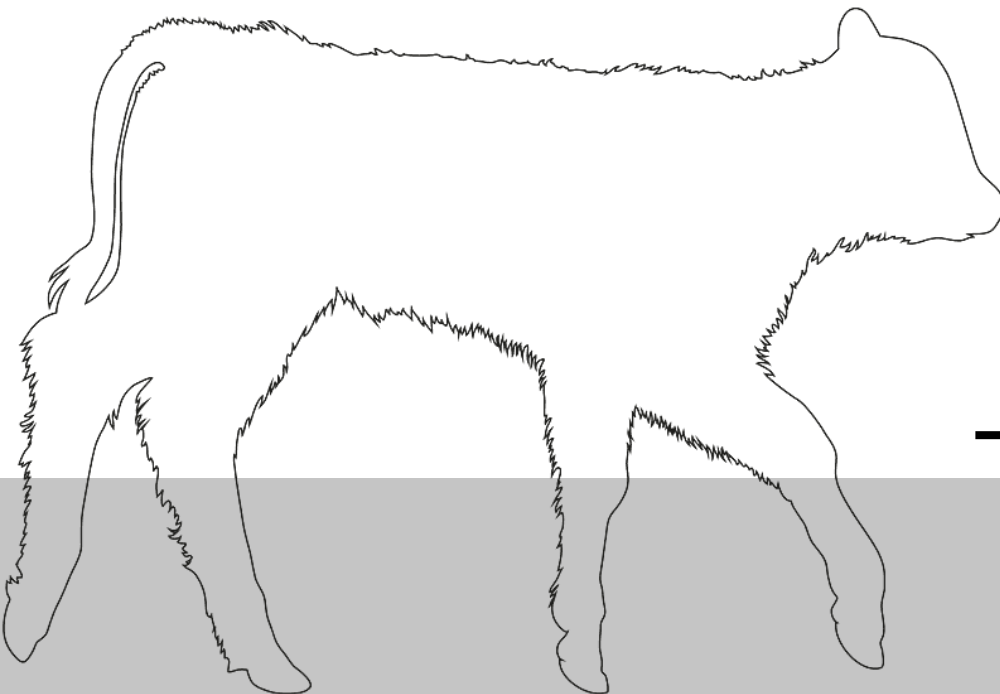
Edna

Design a Calf

Directions:

Once you have determined the phenotypes of your herd, select one bull and one cow to mate. Circle their names. Then, use a quarter to determine the genotype of their offspring. Flip a quarter for each trait for each parent, and use the allele assigned to each side of the quarter. Color the calf below based on the correct phenotype.

	Eugene		Dominic		Geneva		Edna		Your calf		
	Heads	Tails	Heads	Tails	Heads	Tails	Heads	Tails	Bull	Cow	Phenotype
Sex	X	Y	X	Y	X	X	X	X			
Coat color	B	b	b	b	b	b	B	B			
Dilution	d	d	D	D	d	d	d	d			
W. Markings	F	F	f	f	F	F	f	f			
Polled/Horns	P	p	P	p	p	p	P	P			



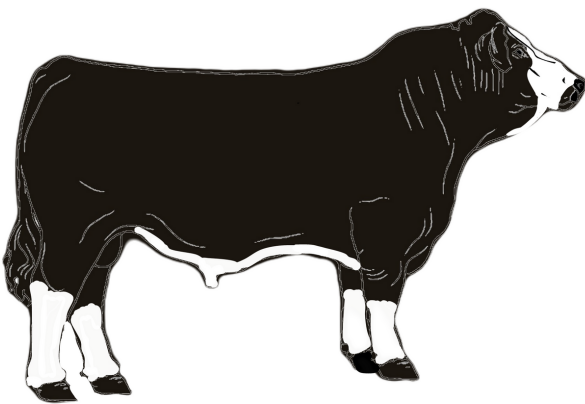
Your calf's name:

Build Your Herd

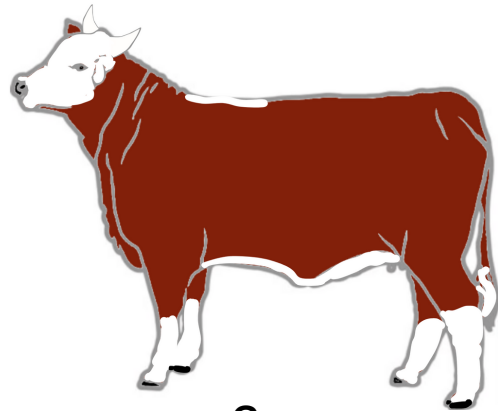
Answer Key

Provided below are the correct answers for this activity.

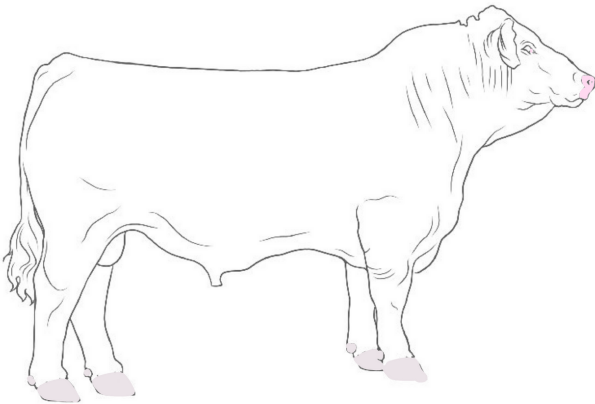
	Eugene	Dominic	Geneva	Edna
Gender	XY (Male)	XY (Male)	XX (Female)	XX (Female)
Coat color	Bb (Black)	bb (Red)	bb (Red)	BB (Black)
Dilution	dd (Full)	DD (White)	dd (Full)	dd (Full)
W. Markings	FF (White)	ff (None)	FF (White)	ff (None)
Polled/Horn	Pp (Polled)	Pp (Polled)	pp (Horned)	PP (Polled)



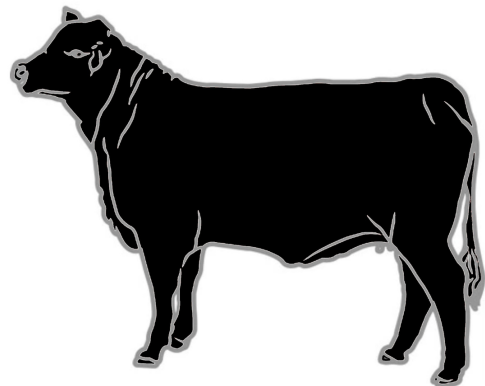
Eugene



Geneva



Dominic



Edna

Design a Calf

Guide

Have students flip a coin for each trait for each parent. The side that it lands on determines the allele students should use. An example is provided for coat color below:

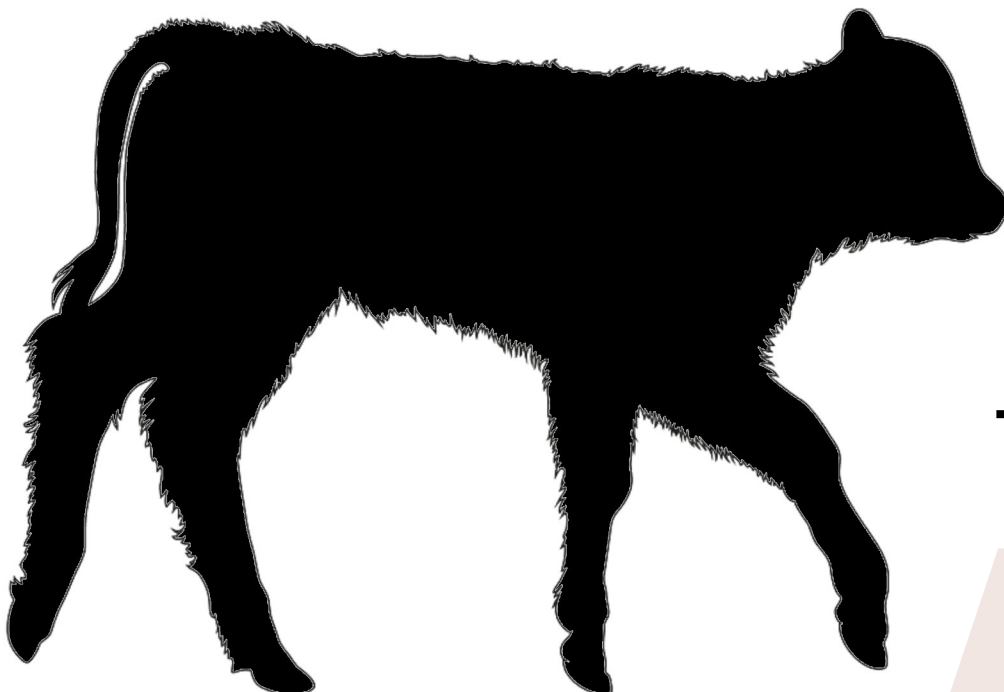


Eugene



Geneva

	Eugene		Dominic		Geneva		Edna		Your calf		
	Heads	Tails	Heads	Tails	Heads	Tails	Heads	Tails	Bull	Cow	Phenotype
Sex	X	Y	X	Y	X	X	X	X			
Coat color	B	b	b	b	b	b	B	B	B	b	Black
Dilution	d	d	D	D	d	d	d	d			
W. Markings	F	F	f	f	F	F	f	f			
Polled/Horns	P	p	P	p	p	p	P	P			



Your calf's name:

Imagene



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