Build-a-Calf Workshop

Credits:
Original lesson by Kelsey Faiver and Will Fett, Iowa Agriculture Literacy Foundation, modified by Jennifer Elwell, TeachKyAg

Grade Levels: 6-9

Purpose: Students will explore concepts of heredity in beef cattle and identify dominant and recessive traits.

Estimated Time: 45 minutes

Materials Needed:

Activity 1

- Kentucky Farms Feed Me Virtual Field Trip – Beef Cattle
- Post-it notes, 3 per student
- Chart paper or whiteboard
- Beef Cattle Placemat or poster (optional)

Activity 2

- Chart paper

Activity 3

- Build-a-Calf Workshop activity sheet, 1 per group
- 1 Dice for each group
- Crayons

Education Standards

LS3.A: Inheritance of Traits
Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (08-LS3-1)

Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (08-LS3-2)

LS3.B: Variation of Traits
In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (08-LS3-2)

LS4.B: Natural Selection
In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (08-LS4-5)

Vocabulary Words:

- **alleles:** one of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome.
- **breed (noun):** a group of animals within a species having a distinctive appearance influenced by human selection.
- **dominant:** a trait that can be expressed only when two copies of the gene is present
- **gene:** a unit of heredity that is transferred from a parent to offspring and is held to determine some characteristic of the offspring
- **genotype:** genetic makeup of an animal or plant
- **heredity:** the passing on of physical or mental characteristics genetically from one generation to another
- **heterogeneous:** trait produced by two different genes or a combination of genes
- **homogeneous:** trait produced by two identical genes
- **inherit(ed):** derive a quality or characteristic genetically from one's parent or ancestors
- **inherited trait:** a genetically determined characteristic or quality that distinguishes someone or something; inherited traits are passed in DNA from parents to their offspring
- **linked genes:** genes that are inherited together or do not assort independently
- **phenotype:** physical features of an animal
- **recessive:** a trait that can be expressed only when two copies of the gene is present.

Explaining Genetics Using Cattle

The study of genetics and heredity are incredibly important to agriculturalists and farmers. **Heredity** is the passing of physical or mental characteristics genetically from one generation to another. For centuries, farmers and ranchers have selected plants and livestock for specific genetically determined characteristics called **traits**. Cattle producers select for animals with traits such as high milk production, large muscles, or structural correctness, among other things. Selecting for these traits allows farmers to create livestock **breeds** that are best suited for their needs, customer desires, and economic sustainability.

Beef type cattle (left) have heavier muscle and more fat than dairy type cattle. Beef cattle convert their feed into meat.

It is easy to see a dairy cow's skeleton structure, because she will not carry a lot of muscle and fat on her body.

Let's first look at the difference between beef type cattle and dairy or milk type cattle. Beef producers try to select characteristics in their cattle such as good marbling (intramuscular fat that contributes tenderness, juiciness and flavor), abundant muscle mass, and good skeletal form. A dairy farmer also looks for good skeletal form but will select a cow that will use the food she eats to make milk instead of meat. While they are both cattle, they have a distinct set of traits that make them look unique. This is their **phenotype**, the small differences that contribute to each organism's unique physical features. It is the organism's **genotype**, or collection of genes, that create the physical phenotype. Genotype = instructions. Phenotype = results.

Most plants and animals have two of every kind of **gene**, a unit of heredity transferred from a parent to the offspring. One comes from their mother, and one comes from their father. Only one gene from each parent is passed to each offspring for a particular **trait.** A simple trait in cattle is whether they have horns or no horns (polled). Keep in mind that both male and female cattle can have horns. If we look at the "horn" gene, it may give the instruction for horns or no horns. These different forms of the horn gene are called **alleles**. Alleles can be either dominant or recessive. **Dominant** alleles overpower recessive alleles and are always expressed in offspring. **Recessive** alleles are only expressed if a recessive allele is inherited from both parents, because they are overpowered by even one dominant allele. This does not mean, however, that recessive traits are not common in organisms.

Horns on cattle is caused by two recessive alleles (hh). This condition is described as **homozygous** (identical alleles). The polled (P) trait or phenotype is dominant and can be expressed by the following allele combinations: PP (homozygous) or Ph (**heterozygous** – different alleles). NOTE: d*ominant alleles are typically noted with a capital letter, and recessive alleles with a lowercase letter.* If you cross a horned cow (hh) with a homozygous polled bull (PP), all the offspring will be polled. This can be determined using a Punnett square. The second example provides results on how traits will be expressed if the parents have heterozygous alleles.

Polled (P) or Horned (h)? **X**		Bull's Alleles	
		P	P
Cow's Alleles	h	Ph	Ph
	h	Ph	Ph

Since both parents are homozygous for different alleles, each calf will be heterozygous polled since the polled trait (P) is dominant. The possible genotypes are expressed in yellow.

Polled (P) or Horned (h)? **X**		Bull's Alleles	
		P	h
Cow's Alleles	P	PP	Ph
	h	Ph	hh

If the bull and cow are heterozygous for the polled trait, ¾ of the calves will be polled, and ¼ will have horns. Also notice there is a 50:50 mix of homozygous and heterozygous offspring.

The polled trait is favored among many cattle breeds for safety and management reasons. With an understanding of the science of genetic inheritance, cattle producers can select for the absence of horns using breeding stock that will produce calves without horns to eliminate the need to dehorn calves after they are born.

Now let's look at coat color. There are three primary cattle coat colors: **Black, Red, and White**. Black is dominant. Red is recessive. A white coat color allele, however, is an example of **incomplete dominance** and will mix with black or red to create a roan pattern (alternating white and colored hair). It is also easy to understand that there may be other genes present that can impact coat color lightness or darkness, the presence of spots, and whether an animal has white on their face, among others. These other coat characteristics are inherited through **linked genes,** and traits may be blended. A light red cow, for instance, has genes for a red coat and for color dilution.




There are numerous **breeds** of beef cattle in the United States and throughout the world. Each breed has distinguishing characteristics that can be passed to their offspring. Angus, which is a very popular beef type breed, are polled (naturally without horns) and either all red or all black in color with black being the dominant color. They are known for their high meat quality and ability to care for calves. Herefords are another popular breed of cattle that can either be polled or horned, have a red coat, and a white face and underbelly. They are larger framed with abundant muscle, but less marbling compared to Angus. Angus and Hereford cattle are often used in crossbreeding programs in hopes of maximizing qualities of both. A Black Angus/Hereford cross can be identified by a white face and all black body, usually with no horns. They are typically known as a "Black Baldy." These crossbred calves are normally a product of an Angus cow bred with a Hereford bull or vice versa. By seeing the black coat color and white face in the offspring, we can hypothesize that those are both dominant traits in each breed.

Crossbred cattle are popular among beef producers because they have been shown to have up to 20% more lifetime productivity over purebreds, which leads to an economic advantage for farmers.

Interest Approach - Engagement

Begin a discussion with students by asking the following questions:

- How are beef cattle different from dairy cattle?
- What are some characteristics of humans that are inherited? Do all humans have identical inherited traits? How are they different or the same?
- What are some characteristics in cattle that can be inherited? Do beef cattle and dairy cattle have the same or different inherited traits?
- Why is inheritance important to a cattle farmer?

Procedures

Activity 1: Beef Cattle K-W-L Chart

1. Begin by passing around a post-it note or small piece of paper to every student. Ask the students to close their eyes. Have them visualize their response to the following question: "What comes to mind when I say the words beef cattle?"
2. Have students jot down what came to their mind on the post-it note. Clarify to students that they can draw a picture or write down a word or phrase that came to their mind.
3. Next, have students place their post-it note into a bucket. Remove the post-it notes one by one and begin to add the student's responses to the K section of a KWL chart drawn on chart paper or the board. These responses reflect what the students **K**now about beef cattle. Discuss responses as they are revealed.
4. After the K section is completed, ask students what they would like to learn about beef cattle. Add their responses to the W section of the KWL chart. These responses will represent what the students **W**ant to learn about beef cattle.
5. Introduce the Kentucky Farms Feed Me Virtual Field Trip on beef cattle to the class. It shows several breeds and cross breeds of beef cattle. They may also view the Beef Cattle poster.
6. Follow the same idea above and have students write on a second post-it note what they **L**earned about beef cattle from the book. Add these responses to the L section of the KWL chart.
7. Compare the W and L sections of the KWL chart to see if the students learned all they wanted to.
8. Next, determine any questions in the W section that were not answered by watching the video or viewing the poster. Place students in small groups based on the number of sticky notes that still need to be researched.
9. Assign each group one sticky note from the W section that still needs to be researched and explored.
10. Once each group has gathered the information needed to answer their question from the W section of the KWL chart, have them add it to a post-it note, share it with the class, and then place the post-it note in the L section of the KWL chart.

Activity 2: Breed Research & Gallery Walk

1. Assign students to small groups and provide them the name of a beef cattle breed.
2. Ask them to research their breed and make a poster detailing the following information:
    a. Photo(s) of the breed
    b. Description of physical characteristics.
    c. Description of temperament characteristics (if available).
    d. Meat characteristics
    e. Where the breed originated.
    f. Popularity of the breed
    g. Reasons why a farmer may want to utilize characteristics of this breed: markets, location, environment, etc.

Activity 3: Build-a-Calf

1. Divide students into groups of four students or less. Give each group a Build-a-Calf activity sheet and have them complete the "Horned or Polled" and the "Black, Red, White, or Roan" sections.
2. Before the "Build a Calf" section, provide each group a dice. Students will use the dice to determine the genotype of their calf, and then they will create a drawing to represent their calf's phenotype. Have each group present their calf to the class.
3. As a group, have students discuss:
    - Are beef producers the only farmers that need to be concerned with genetics? Are there traits in crops or other livestock that are affected by heredity? What might some of those traits be?
    - If an animal lives in an arid desert, what traits might you select? What might help your animal be more successful in that environment?
    - Do the traits in the game directly affect the animal's use for consumers? What are some traits that might directly affect the animal's use for consumers? Is there a way to select for traits that would focus on nutrition or healthfulness?

Conception Elaboration and Evaluation

After conducting these activities, review and summarize the following key concepts.

- Genetics play an important role for beef farms in selecting cattle with specific traits to produce a higher quality product for consumers and to increase food production.
- Different breeds of cattle have distinguishing characteristics that can be transferred to their offspring. This is known as heredity.
- Crossbred cattle provide more desirable traits and lifetime productivity over purebred cattle.

Enriching Activities

- Have students brainstorm traits to add to the list from Activity 3. Some could include: muscle, bone, head color, hair length, hoof size, etc. Are there traits they would like that come from other organisms? This could start a discussion on genetic modification.
- Ask them to draw or describe their perfect "breed" of cattle and share with the group.

Build a Calf Worksheet

Group members:

Polled or Horned?

Use the following Punnett square to determine if the calves will have horns or will be polled (no horns). Remember that polled (P) is the dominant trait to horned (h).

Polled (P) or Horned (h)? **X**		Bull's Alleles	
		P	h
Cow's Alleles	h		
	h		

1. What is the bull's genotype? _____ Is the bull horned or polled? _____
2. Are the cow's alleles homozygous or heterozygous? _____
3. What ratio or percentage of the calves could be polled? _____ Horned? _____

Black, Red, White, or Roan?

Use following Punnett square to determine if the calves will have a black coat or a red coat. Black is dominant (B) to red (b). Hypothesize the results before completing the square.

Black (B) or Red(b)? **X**		Bull's Alleles		Do you think most of the calves will be black or red? Why?
		B	b	
Cow's Alleles	B			
	b			

1. What color is the bull? _____ What color is the cow?_____
2. What ratio or percentage of the calves could be red? _____

Now let's cross the same bull (Bb) with a red roan cow (bw).

X		Bull's Alleles		What is the phenotype for each genotype possibility?
		B	b	
Cow's Alleles	b			1. _____ 2. _____
	w			3. _____ 4. _____

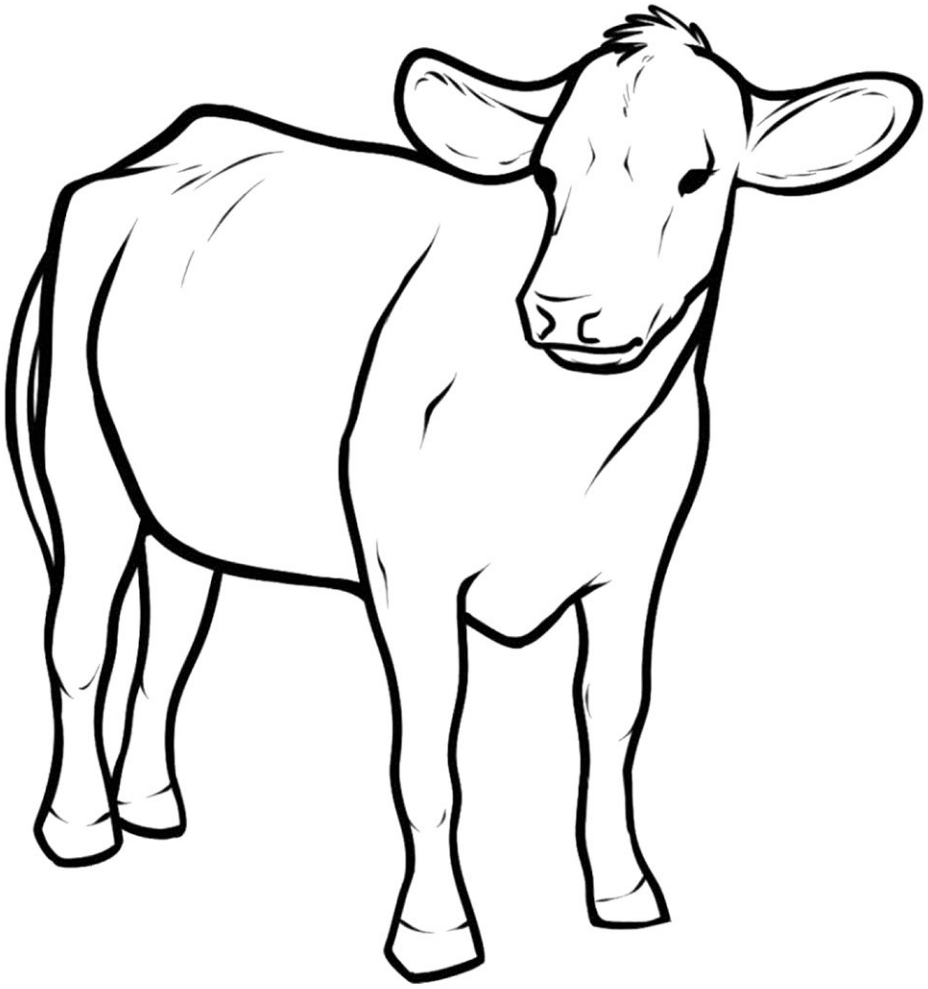
3. Would it be possible for a solid red or black cow to have a white calf? Why or why not?

Build a Calf

Use the dice to determine each of the alleles in your calf's genotype. Since a calf has two parents, you will roll twice for each trait. Use the table to the right to assign an allele for each number rolled. Once you have your genotype, determine the phenotype. Remember that CAPITAL letters are the dominant alleles (white is an exception and will always be expressed through incomplete dominance). Keep in mind that the heredity of spots and patterns on cattle are more complicated than presented in this exercise. Use crayons to create a visual representation of your calf.

Trait	Bull Allele	Cow Allele	Phenotype
	Genotype		
Horned or Polled?			
Coat Color			
Color Dilution			
Spotted Coat			
White Face & Belly			
Belted			

Circle the HOMOZYGOUS genotypes above.



Horned or Polled
Odd # – h (horned)
Even # – P (polled)

Coat color
1/2 – B (black)
3,4,5 – b (red)
6 – w (white)

Color dilution
1/2 - D (dilution)
3,4,5,6 - d (no dilution)
A DD genotype will create a lighter-colored coat than a Dd genotype.

Spotted Coat
1 – S (spotted)
2/6 – s (not spotted)

White Face & Belly
1 – F (white face & belly)
2,3,4 – f (no white)
5 – F (white face & belly)
6 – f (no white)

Belt of White
1 – G (belted)
2/6 – g (no belt)