Coats and Genes: Genetic Traits in Cattle

Grades 6-8

Science

Objectives

The student will read about heredity and explore genetic traits in cattle.

Vocabulary

Allele—one of two or more alternative forms of a gene that controls the same inherited characteristic
DNA (deoxyribonucleic acid)—molecule that contains genetic information and is located in the nucleus of every cell inside an organism
Gene—the basic unit of heredity that serves as a blueprint for each protein product produced in the body of an organism
Genotype—the whole set of genes of an individual or group
Heterozygous—having at least one gene pair that contains different genes
Homozygous—having at least one gene pair that contains identical genes
Phenotype—the visible characteristics of a plant or animal that result from the combined effects of the genes and the environment
Polled—having no horns
Punnett Square—diagram used by scientists to help them to figure out how inherited traits (characteristics) will be distributed
Scurs—incompletely developed horns in cattle and other horned animals

Background

Agriculturists are pioneers in the study of genetics and heredity. For centuries farmers and ranchers have selected plant varieties and livestock for specific traits. Plant breeders select plant varieties which produce more seed or fruit. Livestock producers select animals with specific traits such as increased milk production, ample muscle mass or structural correctness. Selecting for these traits has allowed agriculturalists to produce a higher quality and more abundant food supply.

Heredity is the passing on of traits from parents to offspring. Most plants and animals have two of every kind of **gene**, one from their mother and one from their father. Only one gene from each parent is passed to each offspring for a particular trait. There are different forms of a gene that are referred to as **alleles**. Alleles are forms of the same gene with small differences in their **DNA** sequence. These small differences contribute to each organism's unique physical features. These physical features are called "**phenotypes**."

Some alleles are dominant, while others are recessive. Dominant alleles overpower recessive alleles and are always expressed in offspring. Recessive alleles are only expressed in offspring if both parents contribute a recessive allele. In human eye color, the allele for brown eyes is dominant, and the allele for blue eyes is recessive. Therefore, if the offspring receives a brown eye allele from either parent, the

offspring will have brown eyes. The offspring would have to receive a blue eye allele from each parent to have blue eyes.

In cattle, the allele that causes horns to grow is recessive. The hornless, or **polled**, allele is dominant. There are additional genes that affect horn-like growth on an animal's head. The horn-like growths are called **scurs**. Scurs are incompletely developed horns which are generally loose and movable beneath the skin and not attached to the skull. They range in size from small scab-like growths to occasionally almost as large as horns. Because the gene for scurs is transmitted separately it has no effect on the presence or absence of horns. Not all horned cattle carry the gene for scurs, and not all polled cattle lack the scur gene.

The absence of horns in cattle is a desirable trait for cattle producers because of the safety factor. Producers are also concerned about economically beneficial traits such as growth and reproduction.

One trait that has fascinated cattle breeders for hundreds of years is coat color. Red and black are probably the two most common coat colors in cattle. They occur as an either/or in breeds such as angus and Holstein. In other breeds, modifier genes change the shades of these colors to a much wider range of possibilities. The black gene is dominant over the red gene and causes the hair to be black. The red gene is recessive and causes the production of red pigment only.

Punnett square boxes show the possible combinations of genes that an offspring may receive from its parents. The following diagram is a Punnett square which shows all the possible combinations of two gene sets—Pp and Pp—and the resulting genetic traits. P is the dominant gene for a polled, or hornless, parent; p is the recessive gene for a horned parent.

PUNNETT SQUARE: POLLED OR HORNED IN CATTLE (Hh X Hh)

Polled or Horned Parent	H (polled)	h (horned)
H (dominant trait)	HH = polled	Hh = polled
h (recessive trait)	Hh = polled	hh = horned

OR

The following diagram is a Punnett square which shows all the possible combinations of two gene sets—Pp and pp—and the resulting genetic traits. P is the dominant gene for a polled, or hornless, parent; p is the recessive gene for a horned parent.

PUNNETT SQUARE: POLLED OR HORNED IN CATTLE (Hh X hh)

Polled or Horned Parent	h (horned)	h (horned)
H (dominant trait)	Hh = polled	Hh = polled
h (recessive trait)	hh = horned	hh = horned

Probability is the chance that something will happen. By examining the Punnett square boxes above, we can see that there is a 75% chance of an offspring being polled if both parents have both dominant and recessive genes. There is a 25% chance of the offspring being horned. When both dominant and recessive genes are present (Pp), the condition is called "**heterozygous**." When both genes are either dominant or recessive (PP or pp), the condition is called "**homozygous**." This simple diagram demonstrates how the genetics of one gene functions. Humans, plants and animals have multiple genes which have complex interactions to determine offspring traits.

Background Sources: Kirkpatrick, David F., "Color Patterns in Beef Cattle," University of Tennessee; "Genes for Cowboys," university of Saskatchewan, http://homepage.usask.ca/%7Eschmutz/Cowboys.html

Activity 1: Dominant or Recessive, (Science) 1-3 50 minute class periods

Materials:

- 2 coins
- Activity 1 Worksheet 1- "Dominant or Recessive?"
- Activity 1 Worksheet 2- "Genetic Traits"
- Activity 1 Worksheet 3- "Calf Outline"
- Activity 1 Worksheet 4- "Gene Discussion"
- Black and red pens, markers, pencils, or crayons

Procedure

1. Divide students into pairs, and give each pair a coin and a copy of the "Dominant or Recessive?" worksheet.
2. Students will take turns flipping the coins—one to determine the mother's traits and one to determine the father's traits.
3. If the coin lands on heads, the student will circle the dominant trait. If the coin lands on tails, the students will circle the recessive trait.
4. Students will repeat this process for all seven traits.
5. Once all the traits have been randomly selected from the mother and father, students will transfer the selected traits to the "Genetic Traits" worksheet.
6. Students will circle the appropriate genetic traits which will be expressed in the offspring.
7. Hand out the "Calf Outline" worksheet.
8. Students will each draw and color the calf so that it reflects all the randomly selected genes.
9. Lead a discussion based on these questions:
   —"Are all the calves the same?"
   —"How are the calves different?"
   —"Why are the calves different?"
   —"Let's count the number of calves with no horns. Is it 75 percent of the faces, as the Punnett Square predicted?"
   *Do the same for the other traits.
10. Allow students to repeat the genetic activity (minus coloring the calves) until there are 50 or 100 calves, and compare the results. Are the results the same? Is the percentage of horned cows the same? Other traits?
11. Students will develop a chart and determine the percent of dominant vs. recessive for each trait from both activities.
12. Students will develop a Punnett square diagram for the other traits. Why is there a 50 percent chance of the offspring being female?

Activity 2: Herd of Many Colors, (Science) 1 50 minute class period

Materials:

- Small box for each group with 50 black beans and 50 red beans, as close as possible to same size and shape
- Activity 2 Worksheet 1 "Herd of Many Colors"

Procedure

1. Students remain in pairs for this activity to demonstrate coat color distribution in a herd of cattle.
2. On the board write the basic colors of cattle (black and red) and show which colors are dominant (black > red).
3. Provide each group with a box and 50 each black and red beans. All the beans should be roughly the same size and shape.
4. Explain that each box of beans represents the genetic makeup of a herd of cattle.
5. As a class, list on the board the three possible combinations of beans. (black/black; black/red; red/red)
6. Students will take turns reaching blindly into the boxes to remove two beans at a time.
7. Students will place matching bean combinations in lines or columns on paper to create line graphs.
8. For each pair of beans, students will determine the genotype and phenotype of the calf and record it on a chart of their own design.
9. Students will determine the ratio of black to red cattle in their herds (BLACK= black/black; BLACK= black/red; RED= red/red).

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Standards

Oklahoma Academic Standards

Activity 1: Dominant or Recessive (Science)

MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Activity 2: Herd of Many Colors (Science)

MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Coats and Genes: Genetic Traits in Cattle

Activity 1 Worksheet 1: Dominant or Recessive

Name: _____Date: _____

Class/Hour/Teacher: _____

Some alleles are dominant, while others are recessive. Dominant alleles overpower recessive alleles and are always expressed in offspring. Recessive alleles are only expressed in offspring if both parents contribute a recessive allele. H is the dominant gene for a polled, or hornless, parent; h is the recessive gene for a horned parent. **Flip a coin to determine which sex chromosome and which genetic traits each parent will pass on to the calf. Flip once for cow and again for bull. If the coin lands on HEADS circle Dominate (Dom) Trait. If the coin lands on TAILS circle Recessive (Rec) Trait.**

HEADS TAILS
DOMINATE RECESSIVE

Cow's Traits	**Bull's Traits**	**Calf's Traits**
The Cow is the mother of the calf and is heterogeneous for all traits except gender	The Bull is the father of the calf and is heterogeneous for all traits	Which trait will the calf get from the cow and the bull?

EXAMPLE	**Dom**	**Rec**		**Dom**	**Rec**	**From Cow**	**From Bull**
	E	**e**		**E**	**e**	**E**	**E**
Male/Female (The cow can only pass on the X chromosome when it comes to sex of the offspring)	X	X	Male/Female (The bull can pass on either the X or Y chromosome which means the bull decides the sex of the offspring)	X	Y		
Polled/Horned	H	h	Polled/Horned	H	h		
Black Coat/Red Coat	B	b	Black Coat/Red Coat	B	b		
Solid Coat/Spotted Coat	R	r	Solid Coat/Spotted Coat	R	r		
White Face/Black Face	F	f	White Face/Black Face	F	f		
Solid Legs/Stocking Legs	L	l	Solid Legs/Stocking Legs	L	l		

You might notice some of the letters seem like they don't match the trait name… that's for clarity. A capital S and a lowercase s look very similar when not in context with other letters. That's why we used some different letters for traits!

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Activity 1 Worksheet 2: Genetic Traits

Name: _____Date: _____

Class/Hour/Teacher: _____

In the table below, write the allele combination in the correct order (capital letter first). This combination of letters is called the GENOTYPE. Then find the PHENOTYPE represented by that GENOTYPE and shade in the box.

Genotype—the whole set of genes of an individual or group

Phenotype—the visible characteristics of a plant or animal that result from the combined effects of the genes and the environment

	Genotype	Phenotype		
Sample Trait	EE	big ears EE	big ears Ee	little ears ee
male/female		male XY	female XX	n/a*
polled/horned		polled HH	polled Hh	horned hh
black coat/red coat		black coat BB	black coat Bb	red coat bb
solid/spotted		solid RR	solid Rr	spotted rr
face color		white FF	white Ff	black ff
solid legs/stocking legs		solid LL	solid Ll	stocking ll

Now comes the fun part! You will color the calf on the next page to match your phenotype above!

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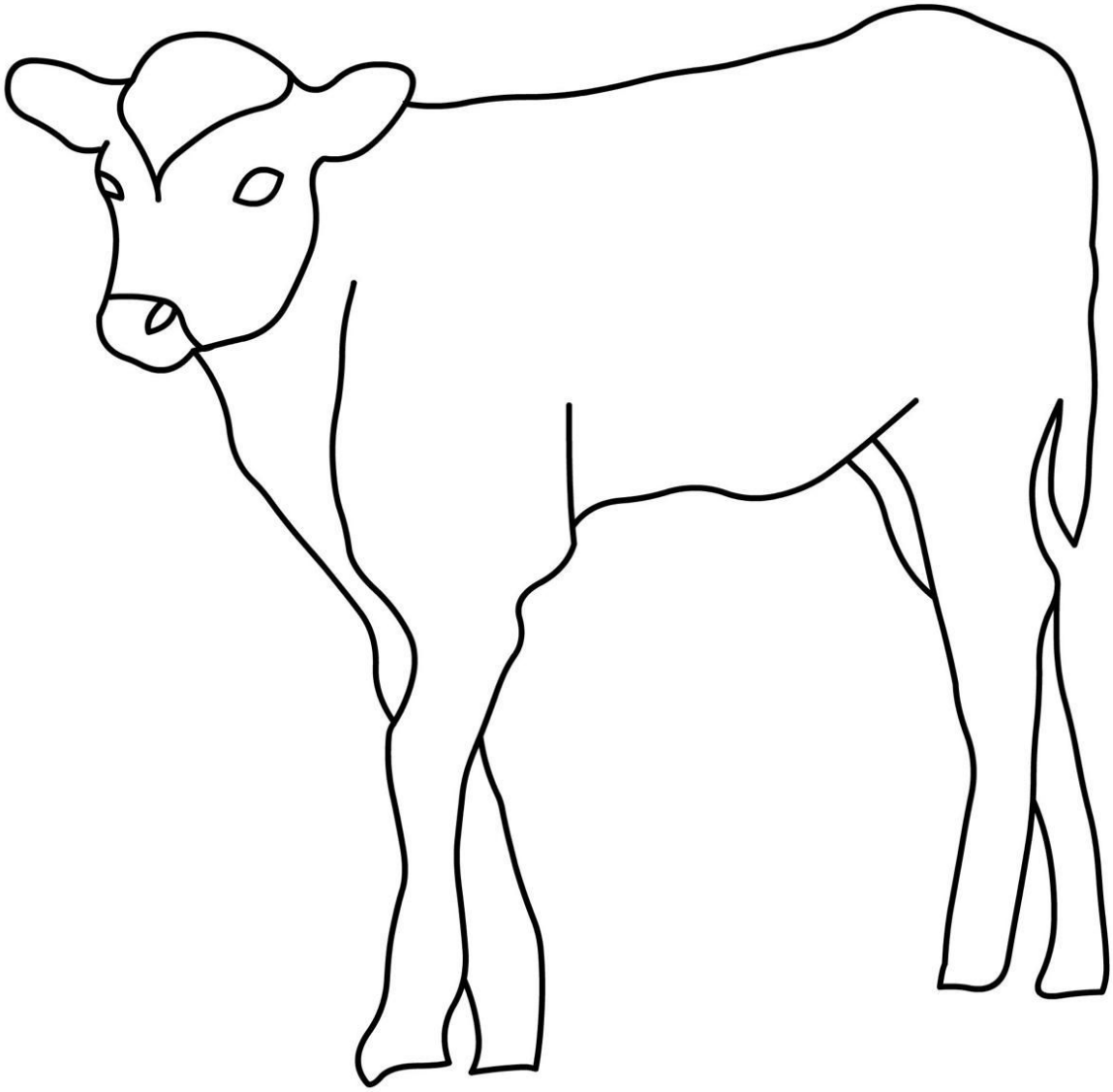
Activity 1 Worksheet 3: Calf Outline

Name: _____Date: _____

Class/Hour/Teacher: _____

Color the calf to match your phenotype from the Genetic Traits Worksheet!



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Activity 1 Worksheet 4: Genetic Discussion

Name: _____Date: _____

Class/Hour/Teacher: _____

GENETIC DISCUSSION QUESTIONS

How many calves are there in the classroom? _____

How many calves are female and how many are male?

Female _____

Male _____

The probability of a calf being female is 50%, does the class set of calves match this probability? _____

Think back to the discussion of probability, if there is a 75% chance a calf will be born polled from 2 heterozygous parents, then 75% of the calves in the classroom should be polled.

How many calves are in the classroom are polled? _____

What percentage of calves are polled? _____

Is this number surprising to you? Why or why not?

What is a heterozygous set of alleles? What about homozygous alleles?

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Activity 2 Worksheet 1: Herd of Many Colors

Name: _____Date: _____

Class/Hour/Teacher: _____

Each box of beans represents the genetic makeup of a herd of cattle. Inside your box, there should be 50 black and 50 red beans. Reach blindly into the box to remove two beans at a time. Place matching bean combinations in lines or columns on paper to create line graphs. Repeat 20 times. For each pair of beans, determine the genotype and phenotype of the calf and record it on a chart of your own design. Determine the ratio of black to red cattle in your herd (Black beans=B, Red beans=b)

What do you predict the probability of a black calf is? _____

What do you predict the probability of a red calf is? _____

Construct a graph to show what you pulled out of the box. This could be a bar graph, a pie chart… you decide. Make sure each type and the count is labeled as you draw beans from the box 20 times. BB=black, Bb=black, bb=red

Based on your data, was your prediction for the probability of a black calf correct?

_____

Based on your data, was your prediction for the probability of a red calf correct?

_____