Coats and Genes: Genetic Traits in Cattle

Grades 9-12

Life 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).

Activity 3: Predicting Generations of Cattle, (Science) 1 50 minute class period

Materials:

- Activity 3 Worksheet 1- "Predicting Generations of Cattle"

Procedure

1. Students will read the worksheet and solve the questions using Punnett Squares.
2. Discuss the results to predict the cattle herds color

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Standards

Oklahoma Academic Standards

Activity 1: Dominant or Recessive (Science)

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Activity 2: Herd of Many Colors (Science)

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Activity 3: Predicting Generations of Cattle (Science)

HS-LS4-1 Analyze and evaluate how evidence such as similarities in DNA sequences, anatomical structures, and order of appearance of structures during embryological development contribute to the scientific explanation of biological diversity.

HS-LS4-2 Construct an explanation based on evidence that biological diversity is influenced by (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

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!

Coats and Genes: Genetic Traits in Cattle

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!

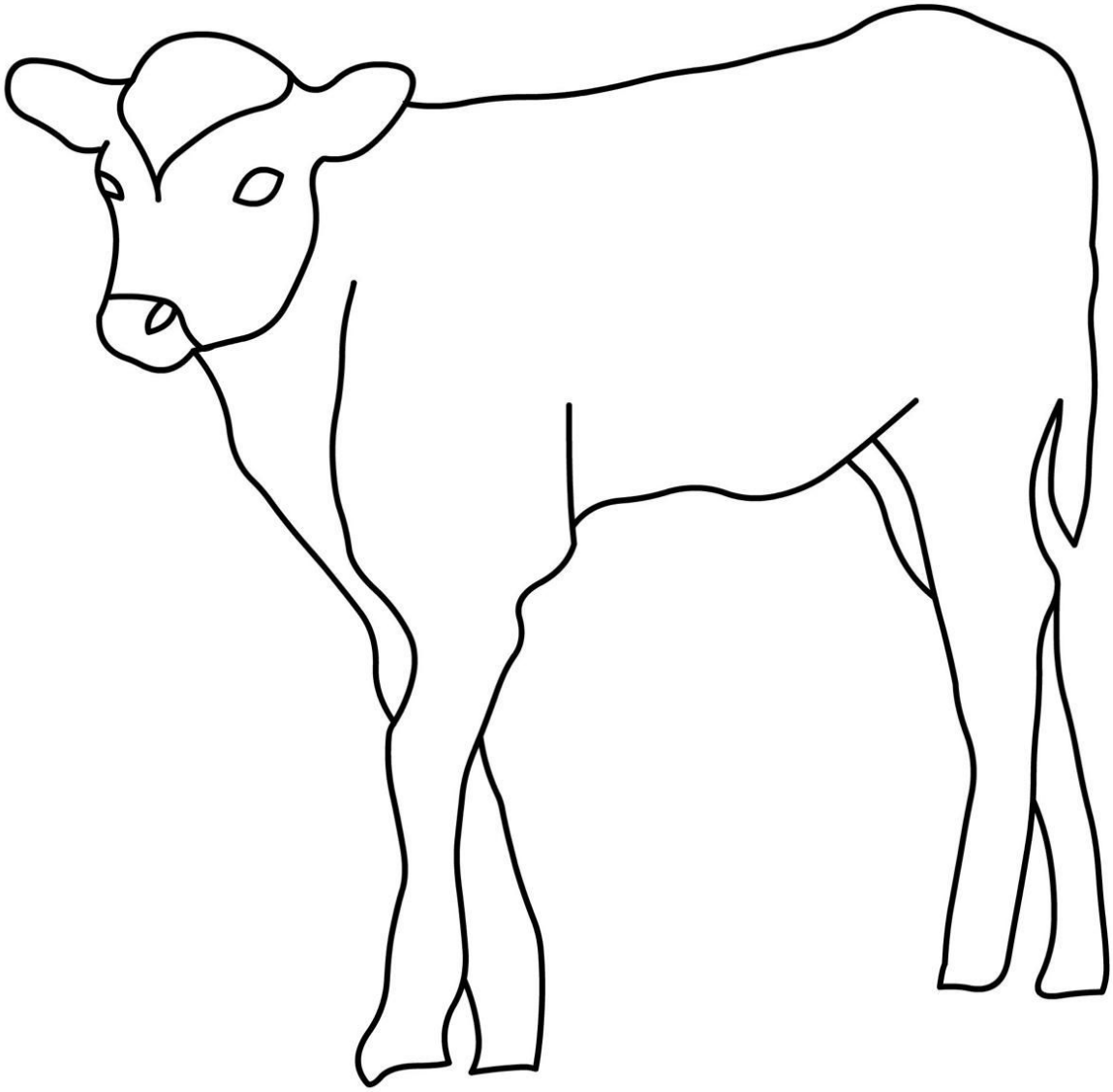
Coats and Genes: Genetic Traits in Cattle

Activity 1 Worksheet 3: Calf Outline

Name: _____Date: _____

Class/Hour/Teacher: _____

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



Coats and Genes: Genetic Traits in Cattle

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?

EXTEND

When both dominant and recessive genes are present (Hh), the condition is called "heterozygous." When both genes are either dominant or recessive (HH or hh), the condition is called "homozygous." In cattle, the allele that causes horns to grow is recessive. The hornless, or polled, allele is dominant.

Construct a Punnett square showing the probable genotype and phenotype of the mating of heterozygous polled bull and a heterozygous polled heifer.

Construct a Punnett square showing the probable genotype and phenotype of a mating of a homozygous horned bull and a heterozygous polled cow.

Coats and Genes: Genetic Traits in Cattle

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 of the different GENOTYPES 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?

_____

Coats and Genes: Genetic Traits in Cattle

Activity 3 Worksheet 1: Predicting Generations of Cattle

Name: _____Date: _____

Class/Hour/Teacher: _____

In cattle, the allele that causes horns to grow is recessive. The hornless, or polled, allele is dominant.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. 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.

DIRECTIONS: Construct an explanation based on evidence explaining what could be influencing the biological diversity of the cattle herds. Apply concepts of statistics and probability to support the explanation that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

1. **A cattle rancher is proud of his all black angus herd. For 100 years he has had all black angus cattle, and it's been his families legacy to own black cattle. Last Spring, he went out to check his herd of 50 cows and found that one of his cows had a red calf. He said, "How can this be? I don't own any red cattle… where did this red calf come from?"**

   a. **Explain how you think this could happen:**

   b. Use a Punnett Square to show how this might be possible.

2. Another cattle rancher has been trying to get into the business of extreme cattle. The other day, he saw a bull that was red with horns, and decided he wanted to have a whole herd of cattle that were red with horns. He decides to by the bull, thinking that if he breeds it to all of his black cows, that he will get half red and half black calves, with half of them being horned and half being polled.

a. **With what you've learned about genetics and dominant and recessive genes, is he right?**

b. **What should he do if he really wants red cattle with horns, but cannot sell all of his cows and buy new ones?**

c. **Use a Punnett Square to support your idea.**

Use this information to solve the following question:

HH= Homozygous polled Hh= Heterozygous polled hh= Homozygous horned
BB= Homozygous black Bb= Heterozygous black bb= Homozygous red

1. **Farmer Brown's fence was down and his heterozygous black polled cow was bred. Three bulls could have been the sire. The calf was born red with horns. Determine which bull(s) could have been the sire, by drawing a Punnett Square for each Bull/Cow combination.**
   Bull 1= Hhbb Bull 2= hhBb Bull 3= HHBB

2. **A black polled bull was bred to a red horned cow. The bull is BbHh, and the cow is bbHh. What are the possible offspring combinations? Draw a Punnett Square to support your answers.**

   a. **What percentage of the calves will be black? _____ red? _____**
   b. **What percentage will be black polled? _____ red polled? _____**
   c. **What percentage of the calves will be horned? _____**

EXTEND

When both dominant and recessive genes are present (Hh), the condition is called "heterozygous." When both genes are either dominant or recessive (HH or hh), the condition is called "homozygous." In cattle, the allele that causes horns to grow is recessive. The hornless, or polled, allele is dominant.

Construct a Punnett square showing the probable genotype and phenotype of the mating of heterozygous polled bull and a heterozygous polled heifer.

Parents Alleles	Bull: H	h
Cow: H	HH	Hh
h	Hh	hh

Construct a Punnett square showing the probable genotype and phenotype of a mating of a homozygous horned bull and a heterozygous polled cow.

Parents Alleles	Bull: h	h
Cow: H	Hh	Hh
h	hh	hh

Coats and Genes: Genetic Traits in Cattle

Activity 3 Worksheet 1: Predicting Generations of Cattle ANSWERS

Name: _____Date: _____

Class/Hour/Teacher: _____

In cattle, the allele that causes horns to grow is recessive. The hornless, or polled, allele is dominant.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. 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.

DIRECTIONS: Construct an explanation based on evidence explaining what could be influencing the biological diversity of the cattle herds. Apply concepts of statistics and probability to support the explanation that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

1. **A cattle rancher is proud of his all black angus herd. For 100 years he has had all black angus cattle, and it's been his families legacy to own black cattle. Last Spring, he went out to check his herd of 50 cows and found that one of his cows had a red calf. He said, "How can this be? I don't own any red cattle… where did this red calf come from?"**

a. **Explain how you think this could happen:**
ANSWERS MAY VARY

b. **Use a Punnett Square to show how this might be possible.**

Parents Alleles	Bull: B	b
Cow: B	BB	Bb
b	Bb	bb

2. Another cattle rancher has been trying to get into the business of extreme cattle. The other day, he saw a bull that was red with horns, and decided he wanted to have a whole herd of cattle that were red with horns. He decides to buy the bull, thinking that if he breeds it to all of his black polled cows, that he will get half red and half black calves, with half of them being horned and half being polled.

a. **With what you've learned about genetics and dominant and recessive genes, is he right?**

Answers can vary, but most likely will be No or Not Necessarily

b. **What should he do if he really wants red cattle with horns, but cannot sell all of his cows and buy new ones?**

Answers may vary, but one might be to keep the cows that have red, horned cattle. Rancher can also keep the calves that are female with red and horns to replace the cows that don't have red, horned cattle. Each year sell a few of the cows that have black polled calves.

c. **Use a Punnett Square to support your idea. Answers should back up statements, one possibility For this Example, Bull is bbhh; Cow is BbHh**

Parents Alleles	Bull: bh	bh	bh	bh
Cow: BH	BHbh	BHbh	BHbh	BHbh
Bh	Bhbh	Bhbh	Bhbh	Bhbh
bH	bHbh	bHbh	bHbh	bHbh
bh	bhbh	bhbh	bhbh	bhbh

Use this information to solve the following question:
HH= Homozygous polled Hh= Heterozygous polled hh= Homozygous horned
BB= Homozygous black Bb= Heterozygous black bb= Homozygous red

2. **Farmer Brown's fence was down and his heterozygous black cow was bred. Three bulls could have been the sire. The calf was born red. Determine which bull(s) could have been the sire, by drawing a Punnett Square for each Bull/Cow combination.**
   Bull 1= bb Bull 2= Bb Bull 3= BB

Bull 1- Yes- 50% chance red calf

Parents Alleles	Bull 1: b	b
Cow: B	Bb	Bb
b	bb	bb

Bull 2- Yes- 25% chance red calf

Parents Alleles	Bull 2: B	b
Cow: B	BB	Bb
b	Bb	bb

Bull 3- No- 0% chance red calf

Parents Alleles	Bull 1: B	B
Cow: B	BB	BB
b	Bb	Bb

2. A black polled bull was bred to a red horned cow. The bull is BbHh, and the cow is bbHh. What are the possible offspring combinations? Draw a Punnett Square to support your answers.

Parents Alleles	Bull: BH	Bh	bH	bh
Cow: bH	BbHH	BbHh	bbHH	bbHh
bh	BbHh	Bbhh	bbHh	bbhh
bH	BbHH	BbHh	bbHH	bbHh
bh	BbHh	Bbhh	bbHh	bbhh

a. **What percentage of the calves will be black? 50% red? 50%**

b. **What percentage will be black polled? 37.5% red polled? 37.5%**

c. **What percentage of the calves will be horned? 25%**