Dairy cattle genetics

Focus questions	How do breeders predict which traits will be present in offspring? How might biotechnology methods improve the process?
Vocabulary	Genotype, phenotype, alleles, homozygous, heterozygous, dominant, recessive, Law of Independent Assortment

Using Punnett squares to show results from a hybrid cross, you can determine the genetic and phenotypic ratios of the offspring. If an animal breeder is interested in creating a better dairy cow, one with some traits from one variety and some traits from another, the traditional method is to cross these two varieties and look for the offspring that exhibit the combination of traits desired.

Cattle breeders look for specific traits in cattle to predict the potential for desirable traits in offspring. Specifically, breeders may prefer polled (hornless) cattle and specific coat color patterns in certain breeds. Polled cattle are often preferred to horned cattle because they do not need to be dehorned, so they pose less of a safety risk to other cows and their caretakers. Coat colors often distinguish dairy breeds and help farmers to predict milk production due to previous knowledge of such dairy breeds. Cattle primarily have three coat color genes: black, red, and white. Black is dominant to red, and black and red are codominant to white. Roan is an equal blending of white hairs with black or red hairs as determined by the animal's genotype.

Genetic traits
- **P:** polled (dominant allele for hornless cattle)
- **h:** horn (recessive allele for horned cattle)
- **B:** black coat color (dominant to red coat color, co-dominant with white coat color)
- **b:** red coat color (recessive to black coat color, co-dominant with white coat color)
- **W:** white coat color (codominant to black and red coat color)

Procedure

Monohybrid cross: A cross looking at one gene for a trait

1. Cross a polled bull with a genotype (PP) with a horned cow with a genotype (hh) in the Punnett square below to show the F1 results. Circle the correct words below:
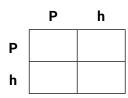   The P P genotype is *homozygous / hetrerozygous and dominant / recessive.*

	P	P
h		
h		

P P × h h
- What are the resulting genotypes? What is the percent?

- What are the resulting phenotypes? What is the percent?

2. When you cross two of the offspring from above, what will be the result in the F2 generation?
   Circle the correct word in the sentence below:
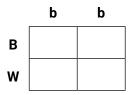   The P h genotype is *homozygous / heterozygous.*

	P	h
P		
h		

   P h × P h
   - What are the resulting genotypes? What are the percents?

   - What are the resulting phenotypes? What are the percents?

3. Cross a red bull (bb) with a black roan cow (BW) in the Punnett square below to show the F1 results. Circle the correct words below:

   The b b genotype is *homozygous / heterozygous.*

   The B W genotype is *dominant / recessive / co-dominant.*

	b	b
B		
W		

   b b × B W
   - What are the resulting genotypes? What are the percents?

   - What are the resulting phenotypes? What are the percents?

Dihybrid cross: Looking at two genes that are on two different chromosomes

4. Cross black polled (BB PP) cattle with red horned (bb hh) cattle in the Punnett square below to show the F1 results.

	BP	BP	BP	BP
bh				
bh				
bh				
bh				

   BB PP × bb hh
   - What are the resulting genotypes?

   - What are the resulting phenotypes?

5. When you cross two of the offspring from above, what will be the result in the F2 generation?

	BP	Bh	bP	bh
BP				
Bh				
bP				
bh				

Bb Ph × Bb Ph
- What are the resulting genotypes?

- What are the resulting phenotypes?

Reflection

1. What are some traits that farmers may value that could be a result of two different cattle breeds?

2. How long might it take for a farmer to know if the cross they have made will result in the desired traits being passed on in offspring?

3. Look for other techniques being used to cut the time required to make new breeds of cattle (i.e., TALEN, gene silencing, CRISPR). Describe how these methods can reduce the time to create new lines that will have increased red coats with polled traits

Rubric for self-assessment

Skill	Yes	No	Unsure
I correctly completed a Punnett square for a monohybrid cross.			
I correctly completed a Punnett square for a dihybrid cross.			
I understand Mendel's Law of Independent Assortment and its impact on the traits in these crosses.			
I discovered at least one new technique in breeding that has impacted the development of new hybrids.			