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GENETIC GAMBLERS

investigating dominant and recessive alleles through phenotypes and genotypes

7.LS3.3 Predict the probability of individual dominant and recessive alleles to be transmitted from each parent to offspring and represent the phenotypic and genotypic patterns using ratios.

INTRODUCTION

When you look in a mirror, which features do you notice first - hair color, eye color, freckles, or dimples? All of these features and more come from your **DNA** - the instructions within the cells of your body that tell it how to grow and develop.

Everyone inherits those instructions through two **alleles** for each trait, one from each biological parent. Alleles are different versions of genes that influence traits. For example, the gene for hair texture may have alleles for straight, wavy, or curly. The combination of alleles each person gets from their parents determines which texture their hair will be. Sometimes, the combination has a **dominant** allele that will "show" when paired with a recessive allele. A recessive trait will show when two recessive alleles are paired together. And that's just the beginning!

A **genotype** (the genetic makeup) is the pair of alleles an organism carries for a trait. A genotype is **homozygous** when the two alleles are the same (HH or hh) and **heterozygous** when they are different (Hh). The **phenotype** (physical appearance) is the observable trait produced by the genotype. By comparing possible allele combinations, scientists can predict the probability of different genotypes and phenotypes in offspring. That's right - by looking at genetics on paper, we can even predict what the trait will look like in real life!

These principles apply to animals and plants just like people. We can put all these ideas together in a **Punnett square**. A Punnett square is a grid we use to predict the genetic makeup and physical appearance of two parents' offspring. We can treat a Punnett square kind of like a puzzle; when we know the parent information, we can make educated predictions about what the offspring might look like. Punnett squares predict probabilities for many offspring; they do not guarantee the traits of one individual offspring.

Suppose we know the genetic information for a female dog (Lady) and a male dog (Skippy). We want to predict the possible fur color their puppies will have.

In dogs, the dominant allele is black fur, represented by H. The recessive allele is golden fur, represented by h. Because we took Lady and Skippy for genetic testing, we know that:

- Lady has the genotype HH and can pass an H allele to each puppy. We list her information on one side of the square. Because we know H is dominant, we know that Lady's phenotype is black fur.
- Skippy has the genotype Hh and can pass either H or h. We list his information on the other side of the square. Skippy has a recessive allele for golden fur but also has a dominant allele for black fur. Because H is dominant, Skippy's phenotype is black fur.

The ultimate question is, can Lady and Skippy have puppies with golden fur? Let's find out!

EXAMPLE Punnett square for **DOG FUR COLOR**

Lady ↓	Skippy ↓	
	H	**h**
H		
H		

To complete a Punnett square, we create every possible combination of alleles from both parents. We do that by taking it one square at a time, combining one allele from Lady and one allele from Skippy. Remember, capital H is dominant. So, you always list the dominant letter first when completing a square. Because the four boxes are equally likely, each box represents a 25% probability.

Lady ↓	Skippy ↓	
	H	**h**
H		
H		

The squares on the left are homozygous - two of the same alleles for black fur (HH). Since black fur is dominant, we know that these squares represent puppies with black fur.

The squares on the right are heterozygous - one of each allele for black (H) and golden (h) fur. Since black fur is dominant, these squares represent puppies that will have black fur but still carry the recessive allele for golden fur.

You might ask, if they don't have golden fur, why does it matter if they have the code for golden fur? Carrying a recessive allele means that the puppy could one day pass on golden fur to their future puppies, even if they don't have golden fur themselves.

Now that all four squares are complete, we can make a prediction about the puppy fur color using a **ratio**. Ratios tell us how much we have of one thing compared to another. For example, if we had 2 apples and 4 oranges, that is a 2:4 ratio of apples to oranges.

First let's predict the genotype ratio. We see two HH, two Hh, and zero hh in our square. Their puppies have a 50/50 chance of having either the HH or Hh genotype. The genotype ratio is 2 HH: 2 Hh: 0 hh, or 1:1:0**.**

Now let's predict phenotype by breaking down the trait shown by each combination.

- HH - H is black fur, so these puppies will have only black fur.
- Hh - H dominates h, so these puppies will also have black fur but carry the recessive allele for golden fur and can pass it down to their puppies.

Lady ↓	Skippy ↓	
	H	**h**
H	**HH**	**Hh**
H	**HH**	**Hh**

Although the genotypes are different, the predicted phenotypes are all the same. In other words, they have a 100% chance (or a 1:0 ratio) of having black fur.

So, even though Skippy carries the recessive allele for golden fur, their puppies can only have black fur.

Imagine how we can use these same ideas to predict traits in humans, plants, and animals!

Can you use Punnett squares and ratios to make an entirely new animal?

MATERIALS

per group of 2 students	*per student*
● 6-sided die ● 4-sided die ● 1 piece of cardstock ● markers	● pen or pencil ● highlighter ● Genetic Gamblers worksheet

PROCEDURE

Imagine: You and your classmates are breeding a new herd of pigs. These pigs have the possibility of some pretty unique features! You and your partner will work together to create one of the new pigs by rolling the dice to gather genetic material from the parent pigs. Then, you will work like scientists to predict the genetic makeup (genotype) and physical appearance (phenotype) of your new pig. Finally, the dice will determine which prediction comes true, and you will create your pig in real life! By the end of the experiment, you and your classmates will populate the classroom pasture with a herd of unique pigs.

PART ONE: ROLLING FOR PARENT GENOTYPES

1. Get into groups of two, choose an appropriate team name, and write it on the worksheet.
2. Assign one partner to be Parent A and the other Parent B. Record this on the Genetic Gamblers Worksheet.
3. Your pig will get half its genetics from you and the other half from your partner. Parents A and B will take turns rolling the 6-sided die to determine each parent pig's genotype. You will do this for five traits: coat pattern, horn shape, nose shape, number of legs, and ear shape.
4. Parent A will roll the die once for the trait of COAT PATTERN.
    a. Roll a 1 or 2, the parent genotype is homozygous dominant (DD)
    b. Roll a 3 or 4, the parent genotype is heterozygous (Dd)
    c. Roll a 5 or 6, the parent genotype is homozygous recessive (dd)
    d. Record your alleles in the Punnett square under Parent A, COAT PATTERN
5. Parent B will repeat step 4 and record their result under Parent B, COAT PATTERN.
   Let's look at an example.
    - Parent A rolled a 2, Parent A's genotype is DD.
    - Parent B rolled a 4, Parent B's genotype is Dd.
6. Repeat for all characteristics listed on the Genetic Gamblers worksheet until all Punnett squares have parent material, like the example.
7. At the end of this step, your squares will still have many blank spaces.

EXAMPLE Punnett square for **COAT PATTERN**

	PARENT B ↓	
PARENT A ↓	**D**	**d**
D		
D		

PART TWO: PREDICTING GENOTYPE AND PHENOTYPE

1. Let's revisit our example from Part One to see it completed.

   Remember, the dominant coat pattern is D - polka dots. The recessive coat pattern is d - stripes.

   What is the phenotype of a DD coat pattern?

   _____

   What is the phenotype of a Dd coat pattern?

   _____

2. Using what you know about dominant and recessive genetics, complete each Punnett square and determine the genotype and phenotype ratios on the Genetic Gamblers Worksheet like the example above.

EXAMPLE Punnett square for **COAT PATTERN**

PARENT A ↓	PARENT B ↓ **D**	**d**
D	DD	Dd
D	DD	Dd

How do we calculate the ratios?
After you complete a Punnett square:

1. **Count the genotypes** in the four boxes.
2. Write the genotype ratio in this order:
   homozygous dominant: heterozygous: homozygous recessive
3. **Identify the phenotype** for each box.
4. Count how many show the dominant trait and how many show the recessive trait.
5. Write the phenotype ratio.

Remember:
Genotype = the letters
Phenotype = what you can see

Example:

If your Punnett square shows:
DD, Dd, Dd, dd

Then:
Genotype ratio:
1 DD: 2 Dd: 1 dd = **1:2:1**
If D = polka dots and d = stripes:

- DD = polka dots
- Dd = polka dots
- Dd = polka dots
- dd = stripes

Phenotype ratio:
3 polka-dot pigs: 1 striped pig = **3:1**
For Lady and Skippy:

- **Genotypes:** 2 HH: 2 Hh: 0 hh = **1:1:0 genotype ratio**
- **Phenotypes:** 4 black fur and 0 golden fur = **1:0 phenotype ratio**

PART THREE: BIRTHING YOUR PIGS

1. It's time for your pig to be born! So far, you've predicted the likelihood of many traits. Now, just like in real life, chance will determine which of those possible outcomes occurs.
2. Using the 4-sided die, you will roll once per trait. The number you roll determines possible outcome becomes your pig's trait.
    a. Roll a 1, square 1 wins
    b. Roll a 2, square 2 wins
    c. Roll a 3, square 3 wins
    d. Roll a 4, square 4 wins
3. Fill in the winning square with your highlighter.
4. Repeat this until you have a winning square for each trait.
5. Record the genotype and phenotype for each trait in Table 6 on the Genetic Gamblers Worksheet. When this step is complete, you will have the full genetic blueprint to make your pig in real life!

EXAMPLE Punnett square		
PARENT A ↓	PARENT B ↓	
	1	2
	3	4

PART FOUR: PIGS COME TO LIFE!

1. Using the sheet of cardstock and markers, draw your pig and give it the traits from Table 6 on the Genetic Gamblers Worksheet.
2. **Your pig *must* have all five traits you determined through the Punnett squares**.
3. When your pig is complete, give it a name! Cut out your pig and make sure to write the pig's name and your team's name somewhere on the back of your pig.
4. When instructed by your teacher, place your pig in the classroom pasture, being careful not to damage the other pigs.
5. Once instructed by your teacher, take a look around the pasture to view the new herd of pigs, then complete the analysis and conclusion below.

Genetic Gamblers Analysis + Conclusion
A. What similarities does your pig have with others in the class?
B. How did chance factor into creating your new pig? How does that relate to real life genetics?
C. Why is it important to understand recessive alleles, even if we cannot see them expressed in a phenotype?
D. How does the class herd of unique pigs relate to a real-life herd of pigs? How is it different from real life?
E. How can you use a Punnett square to make predictions?