NAME _____ DATE _____

9

MENDEL'S LAWS

PROBLEM How can the characteristics of offspring be predicted?

The science of genetics began in the middle of the nineteenth century. Although animal and plant breeding was practiced before that time, the science underlying it was not fully understood. The results of crosses between organisms could not always be predicted. Moreover, the production of animals and plants with desired traits could not be fully controlled. In 1866, the Austrian monk and scientist Gregor Mendel published the first systematic genetic study. From crosses he made with garden peas, he developed three important laws of heredity. These laws can be used to predict the results of crosses between plants or between animals.

In his studies of the garden pea, Mendel observed that some traits, such as seed color and stem length, are determined by pairs of hereditary units, which are called genes today. Mendel found that each gene pair separates, or segregates. This happens when organisms form sex cells, or gametes. One gamete receives one gene of the gene pair. A second gamete receives the other gene. This observation of Mendel's is called the law of segregation.

A new plant or animal is formed when a male and a female gamete come together to form a zygote. The genes carried by these gametes are distributed according to the laws of chance. Which male gamete fertilizes which female gamete also occurs according to the laws of chance. Mendel recognized that the laws of chance could be used to predict the outcome of a cross. This conclusion of Mendel's is called the law of independent assortment.

The law of dominance is another hereditary law developed by Mendel. In his experiments with the garden pea, he crossed two homozygous, or true-breeding, plants that had contrasting traits. Mendel observed that all the offspring of this cross had the trait of the same parent. He called this trait the dominant trait. The trait that failed to appear in the offspring he called the recessive trait. However, when Mendel crossed two of the offspring, the recessive trait reappeared. Crosses involving a single unmatched gene pair are called monohybrid crosses. Crosses involving two unmatched gene pairs are called dihybrid crosses, while those involving three unmatched gene pairs are called trihybrid crosses.

PURPOSE

The purpose of this investigation is to develop skill in predicting crosses using Mendel's laws and the Punnett square. You will also learn how the laws of chance play an important role in the study of genetics.

MATERIALS (per student)

Pencil

PROCEDURE

PART A Constructing Punnett Squares

1. Examine Figure 9-1a. The capital letter T is used to represent the dominant gene for tallness in the stem length for pea plants. The lower-case letter t is used to represent the recessive gene for shortness in pea plants.

2. Notice the gene combinations, or genotypes, that result from the parental generation (P_1) cross between a female purebred tall (TT) pea plant and a male recessive short (tt) pea plant. All of the offspring that make up the first filial generation (F_1) are all hybrid tall. Their phenotypes, or visible characteristics, are all tall.

3. Figure 9-1b shows the results of a monohybrid cross between the offspring from the F_1 generation. Observe the genotype and phenotype ratios for the second filial generation (F_2).

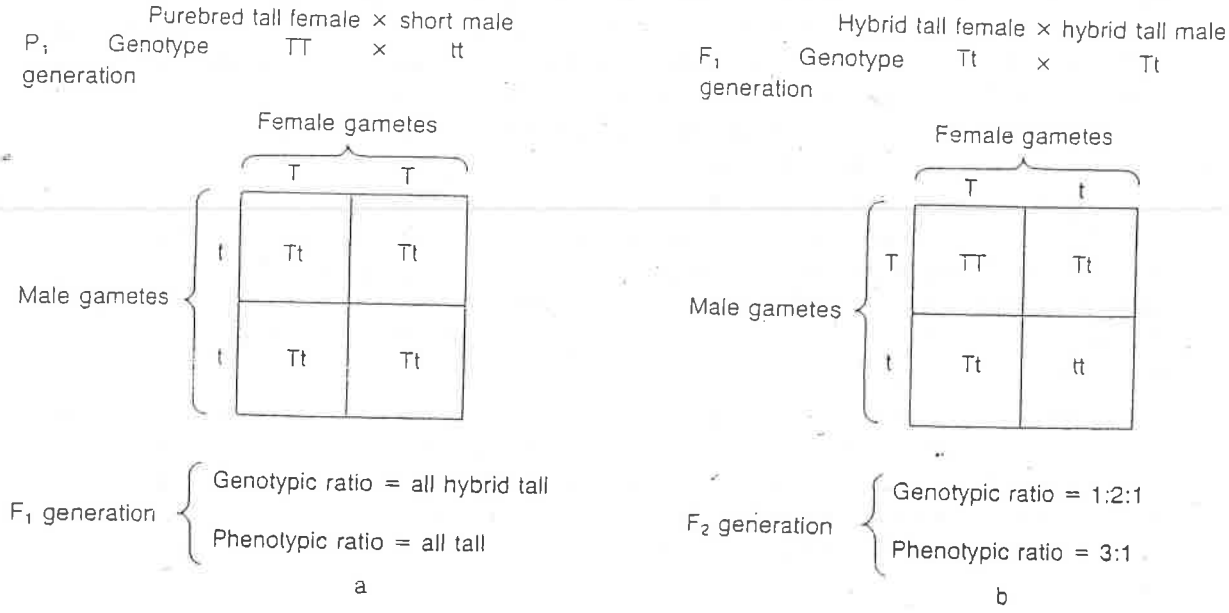

FIGURE 9-1 Results of P_1 and F_1 Generation Crosses

PART B Monohybrid Cross

1. In soybeans, purple flower color is dominant and white flower color is recessive. P represents the dominant gene (purple), and p stands for the recessive gene (white).

2. Predict the probable genotypes of the first generation (F_1) of offspring by crossing the P_1 generation in Figure 9-2 a. Using Figure 9-2 b, cross two plants from the F_1 generation. Write the appropriate genotypes for this cross on the lines provided. Predict the probable genotypes of this cross by filling in the Punnett square.

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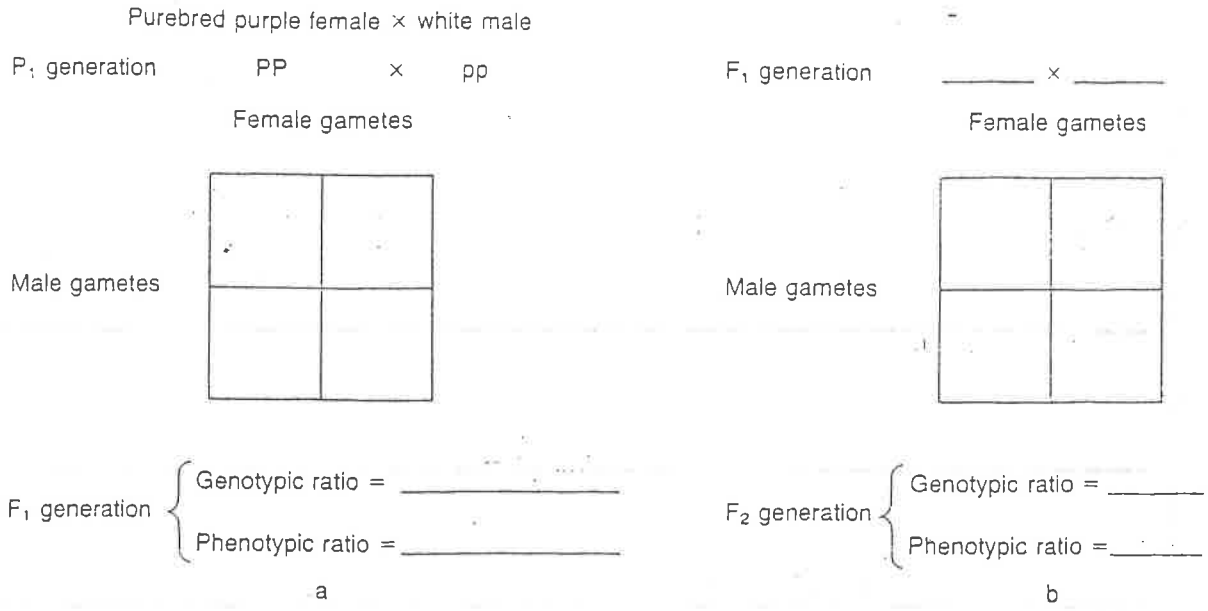

FIGURE 9-2 P_1 and F_1 Generation Crosses

3. Indicate the genotype ratios as follows. Write the number of purebred dominant offspring : the number of hybrid offspring : the number of recessive offspring. Indicate the phenotypic ratio by writing the number of offspring that exhibit the dominant trait : those that exhibit the recessive trait.

PART C Dihybrid Cross

1. In summer squash, white color and disk shape are dominant, while yellow color and spherical shape are recessive. *W* represents the gene for white color and *w* for yellow color. D represents the gene for disk shape and d for spherical shape.

2. In Figure 9-3, the genotypes of a P_1 and F_1 generation are shown. In the F_1 generation, the two squashes are hybrid for each of the two traits. Predict the probable genotypes of the offspring by filling in the Punnett square. Notice that each of these two pairs of genes separates independently during gamete formation. The first column has been filled in to aid you in completing the remainder of the Punnett square.

P_1 generation WWDD × wwdd

F_1 generation WwDd × WwDd

Male gametes \ Female gametes	WD	Wd	wD	wd
WD	WWDD			
Wd	WWDd			
wD	WwDD			
wd	WwDd			

FIGURE 9-3 A Dihybrid Cross

3. After you have completed the Punnett square, fill in Figure 9-4.

Genotype	*Genotypic frequency*	*Phenotype*	*Phenotypic frequency*

FIGURE 9-4 Results of a Dihybrid Cross

PART D Trihybrid Cross

1. In the guinea pig, black coat (B) is dominant over white coat (b). Rough coat (R) is dominant over smooth coat (r). Short hair (S) is dominant over long hair (s).

2. Record the results of a cross between two guinea pigs that are hybrid for each of these three traits. Fill in the Punnett square in Figure 9-5.

P_1 generation BBRRSS × bbrrss

_____ × _____

F_1 generation

Female gametes

Male gametes	BRS	BRs	BrS	Brs	bRS	bRs	brS	brs
	BBRRSS	BBRRSs	BBRrSS	BBRrSs	BbRRSS	BbRRSs	BbRrSS	BbRrSs
	BBRRSs	BBRRss	BBRrSs	BBRrss	BbRRSs	BbRRss	BbRrSs	BbRrss
	BBRrSS	BBRrSs	BBrrSS	BBrrSs	BbRrSS	BbRrSs	BbrrSS	BbrrSs
	BBRrSs	BBRrss	BBrrSs	BBrrss	BbRrSs	BbRrss	BbrrSs	Bbrrss
	BbRRSS	BbRRSs	BbRrSS	BbRrSs	bbRRSS	bbRRSs	bbRrSS	bbRrSs
	BbRRSs	BbRRss	BbRrSs	BbRrss	bbRRSs	bbRRss	bbRrSs	bbRrss
	BbRrSS	BbRrSs	BbrrSS	BbrrSs	bbRrSS	bbRrSs	bbrrSS	bbrrSs
	BbRrSs	BbRrss	BbrrSs	Bbrrss	bbRrSs	bbRrss	bbrrSs	bbrrss

FIGURE 9-5 A Trihybrid Cross

3. After you have completed the Punnett square, fill in Figure 9-6.

Phenotypes	*Phenotypic frequency*
Black, rough, and short-haired	
Black, rough, and long-haired	
Black, smooth, and short-haired	
Black, smooth, and long-haired	
White, rough, and short-haired	
White, rough, and long-haired	
White, smooth, and short-haired	
White, smooth, and long-haired	

FIGURE 9-6 Results of a Trihybrid Cross

OBSERVATIONS AND CONCLUSIONS

PART A

1. When two true-breeding plants with contrasting traits are crossed, what are the genotypes of the offspring?

_____

2. What is the genotypic ratio for a monohybrid cross?

_____

PART B

1. In the monohybrid cross, what are the genotypes of the parent plants in the P_1 generation?

_____

2. What are the genotypes of the parent plants in the F_1 generation?

_____

3. What is the characteristic phenotypic ratio for a monohybrid cross?

_____

4. a. What percentage of the F_2 generation is expected to be purple?

_____

b. What percentage of the F_2 generation is expected to be white?

_____

1. In the dihybrid cross, what are the genotypes of the parent squash in the P_1 generation?

2. What are the genotypes and phenotypes of the F_1 generation?

3. What is the characteristic phenotypic ratio for a dihybrid cross?

4. From Figure 9-4, calculate the percentage of the offspring that is expected to be

   white, disk-shaped

   white, spherical

   yellow, disk-shaped

   yellow, spherical

PART D

1. What are the genotypes of the parents in the P_1 generation of guinea pigs?

2. What are the genotypes and phenotypes of the F_1 generation?

3. From Figure 9-6, what is the phenotypic ratio for the trihybrid cross?

FOR FURTHER INVESTIGATION

1. Albinism is an inherited condition in which there is an absence of the pigment melanin in the eyes, skin, and hair. This condition is transmitted as a recessive trait. Suppose that a woman with this condition marries a man without genes for this trait. Use a Punnett square to determine the probable percentage of their children who will have this condition.

2. Genetic counseling is an important area of preventive medicine. Many human diseases, such as phenylketonuria, are inherited as recessive traits. Obtain information about phenylketonuria and do a report on how a knowledge of genetics is useful in preventing it.