



Name _____

Course/Section _____

Date _____

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Activity 14.3 A Quick Guide to Solving Genetics Problems

Over the years, rules have been developed for setting up genetics problems and denoting genes and their alleles in these problems. This activity provides a quick review of some of these rules. After you have read through all of this material, complete Activities 14.4, 15.1, and 15.2.

Basic Assumptions to Make When Solving Genetics Problems

1. Are the genes linked?

If the problem does not (a) indicate that the genes are linked or (b) ask whether the genes are (or could be) linked, then you should assume that the genes are not linked.

2. Are the genes sex-linked?



Similarly, if the problem does not (a) indicate that the genes are sex-linked (that is, on the X chromosome) or (b) ask whether the genes are (or could be) on the X chromosome (or Y chromosome), then you should assume that the genes are on autosomes and are not sex-linked.

3. Is there a lethal allele?

If a gene is lethal, then you should assume that the offspring that get the lethal allele (if dominant) or alleles (if homozygous recessive) do not appear; that is, they are not born, do not hatch, and so on. Therefore, they are not counted among the offspring. (An obvious exception is lethal genes that have their effect late in life. If this is the case, however, it should be noted in the question.)

4. Are the alleles dominant, recessive, or neither?

Unless the problem states otherwise, assume that capital letters (*BB*, for example) designate dominant alleles and lowercase letters (*bb*, for example) indicate recessive alleles. When there is codominance or incomplete dominance, the alleles are usually designated by the same capital letter and each one is given a superscript (for example, $C^R C^W$ in Figure 14.10, page 261, of *Biology*, 7th edition).



5. How are genotypes written?

Assume a gene for fur color in hamsters is located on the number 1 pair of homologous autosomes. Brown fur (B) is dominant over white fur (b). The genotype for fur color can be designated in different ways:

- a. The alleles can be shown associated with the number 1 chromosome. In this notation, an individual heterozygous for this gene is designated as $1^B 1^b$.
- b. Most commonly, this notation is simplified to Bb .

In problems that involve sex-linked genes, the chromosomes are always indicated—for example, $X^A X^a$ and $X^a Y$.

6. What information do you need to gather before trying to solve a genetics problem?

Before trying to solve any problem, answer these questions:

- a. What information is provided? For example, what type of cross is it? Is it a monohybrid or dihybrid cross? Are the genes sex-linked or autosomal? Linked or unlinked?
- b. What does the information provided tell you about the gene(s) in question? For example:
 - What phenotypes can result?
 - How many alleles does the gene have?
 - Are the alleles of the gene dominant? Recessive? Codominant?
- c. Does the question supply any information about the individuals' genotypes? If so, what information is provided?
 - Grandparent information?
 - Parental (P) information?
 - Gamete possibilities?
 - Offspring possibilities?

Solving Genetics Problems

1. What is a Punnett square?

Punnett squares are frequently used in solving genetics problems. A Punnett square is a device that allows you to determine all the possible paired combinations of two sets of characteristics. For example, if you wanted to determine all the possible combinations of red, blue, and green shirts with red, blue, and green pants, you could set up this Punnett square:

		Shirts		
		Red shirt	Blue shirt	Green shirt
Pants	Red pants			
	Blue pants			
	Green pants			

Similarly, if you wanted to determine the probability of a male (XY) and a female (XX) having a son or a daughter, you would first determine the possible gametes each could produce and then set up a Punnett square to look at all the possible combinations of male and female gametes. Here meiosis dictates that the female gametes get one of her X chromosomes or the other. In the male, the gametes get either the X chromosome or the Y. As a result, the Punnett square would look like this:

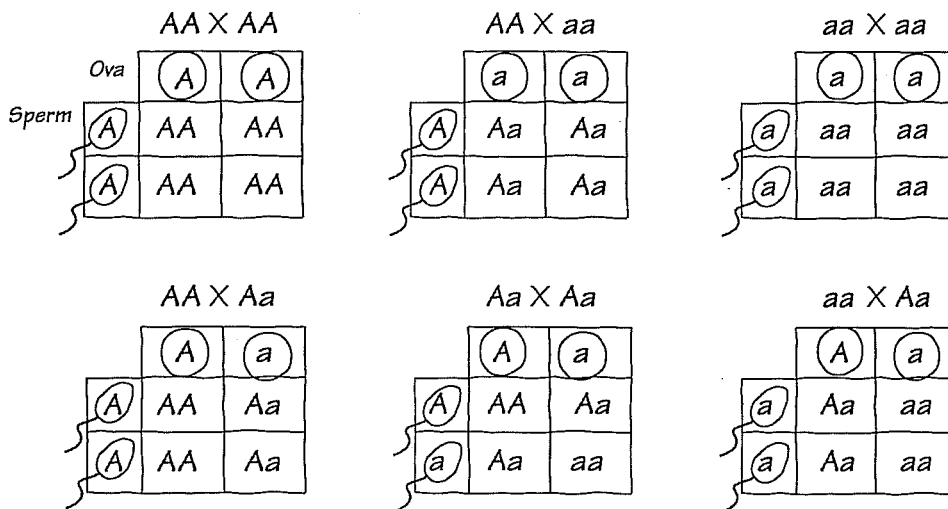
		Female's gamete possibilities	
		X	X
Male's gamete possibilities	X	XX	XX
	Y	XY	XY

2. If you know the parents' genotypes, how can you determine what types of offspring they will produce?

- a. **Autosomal genes:** For an autosomal gene that has the alleles A and a , the three possible genotypes are AA , Aa , and aa .

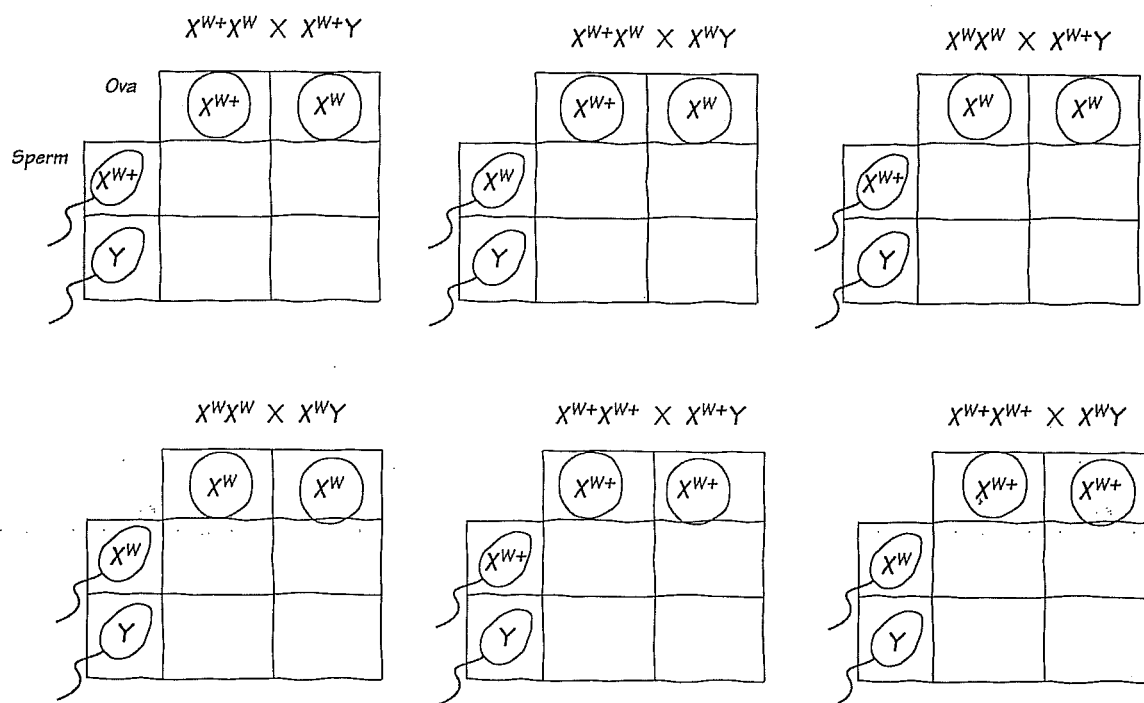
All possible combinations of matings and offspring for two individuals carrying the autosomal gene with alleles A and a are shown in the figure below.

If you know how to solve these six crosses you can solve any problem involving one or more autosomal genes.



- b. **Sex-linked genes:** For sex-linked genes, females have three possible genotypes: $X^{W+}X^{W+}$, $X^{W+}X^W$, and $X^W X^W$. Males have only two possible genotypes: $X^{W+}Y$ and $X^W Y$. All the possible combinations of matings and offspring for a sex-linked trait are listed in the next figure. If you know how to solve these six single-gene crosses, then you can solve any genetics problem involving sex-linked genes.

All possible combinations of matings and offspring for two individuals with a sex-linked gene are shown in the figure below.



c. **Multiple genes:** Remember, if genes are on separate chromosomes, then they assort independently in meiosis. Therefore, to solve a genetics problem involving multiple genes, where each gene is on a separate pair of homologous chromosomes:

- Solve for each gene separately.
- Determine probabilities for combination (multiple-gene) genotypes by multiplying the probabilities of the individual genotypes.

Example:

What is the probability that two individuals of the genotype $AaBb$ and $aaBb$ will have any $aabb$ offspring?

To answer this, solve for each gene separately.

A cross of $Aa \times aa$ could produce the following offspring:

	<i>A</i>	<i>a</i>	$\%aaAa$ and $\%aaa$ offspring
<i>a</i>	<i>Aa</i>	<i>aa</i>	
<i>a</i>	<i>Aa</i>	<i>aa</i>	

A cross of $Bb \times Bb$ could produce the following offspring:

	<i>B</i>	<i>b</i>	$\dots BB, \%Bb, \text{ and } \dots bb$ offspring
<i>B</i>	<i>BB</i>	<i>Bb</i>	
<i>b</i>	<i>Bb</i>	<i>bb</i>	

The probability of having any $aabb$ offspring is then the probability of having any aa offspring times the probability of having any bb offspring.

The probability is $\frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$.