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Activity 14.1 A Genetics Vocabulary Review

Mendel did not know anything about chromosomes, genes, or DNA. Because modern genetics uses vocabulary that assumes students today understand these ideas, it's helpful to review some key terms.

Match each commonly used genetics term with its appropriate definition or example.

Terms	Definitions and Examples
_____ heterozygous	a. Blue-eyed blonde mates with brown-eyed brunette
_____ homozygous	b. *BB* or *bb*
_____ monohybrid cross	c. not on sex chromosomes
_____ autosomal	d. blue or brown eyes
_____ genotype	e. *Bb*
_____ phenotype	f. locus on a chromosome that codes for a given polypeptide
_____ gene	g. Blonde mates with brunette
_____ allele	h. *BB*, *Bb*, or *bb*
_____ dihybrid cross	i. Males have only one for each gene on the X chromosome

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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^RC^W in Figure 14.10, page 272, of *Biology,* 8th 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 $|^{B}\ |^{b}$.

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?

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Activity 15.1 Solving Problems When the Genetics Are Known

Refer to Activity 14.3 and to Chapters 14 and 15 in *Biology,* 8th edition, to complete this activity.

1. An organism that has the genotype *AaBbCc* is crossed with an organism that has the genotype *AABbCc*. Assume all genes are on separate sets of chromosomes (that is, they are not linked).

   a. What is the probability that any of the offspring will have the genotype *AABBCC*? (*Hint:* To get the answer, consider the six possible types of autosomal crosses. Determine the individual probabilities of getting *AA* offspring from the monohybrid cross. Then do the same to determine the probabilities of getting *BB* offspring and *CC* offspring. Multiply these probabilities together.)

   b. What is the probability that any of the offspring will have the genotype *AaBbcc*?

2. Consider the cross *AaBbCcddEe* × *AABBccDDEe*.

   a. What is the probability that any offspring will have the genotype *AaBBCcDdEE*?

   b. What is the probability that any offspring will have the genotype *AABBCCDDee*?

3. In fruit flies (*Drosophila melanogaster*), the most common eye color is red. A mutation (or allele) of the gene for eye color produces white eyes. The gene is located on the X chromosome.

   a. What is the probability that a heterozygous red-eyed female fruit fly mated with a white-eyed male will produce any white-eyed offspring?

   b. What is the probability that the mating in part a will produce any white-eyed females?

   c. What is the probability that this mating will produce any white-eyed males?

4. A heterozygous brown-eyed human female who is a carrier of color blindness marries a blue-eyed male who is not color-blind. Color blindness is a sex-linked trait. Assume that eye color is an autosomal trait and that brown is dominant over blue. What is the probability that any of the offspring produced have the following traits?

   a. Brown eyes

   b. Blue eyes

   c. Color blindness

   d. Color-blind males

   e. Brown-eyed, color-blind males

   f. Blue-eyed, color-blind females

   g. What is the probability that any of the males will be color-blind?

   h. Why do males show sex-linked traits more often than females?

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Activity 15.2 Solving Problems When the Genetics Are Unknown

An understanding of Mendelian genetics allows us to determine the theoretical probabilities associated with normal transmission of autosomal and sex-linked alleles during reproduction. This understanding provides us with strategies for solving genetics problems. In real-life situations, geneticists use these strategies to determine the genetics behind specific phenotypic traits in organisms. They do this by conducting controlled crosses of experimental organisms (e.g., *Drosophila*) or by analyzing family pedigrees (as for humans).

Controlled Crosses

Two problems are presented below. In each, you are given:

a. "Wild population"—the phenotypic characteristics of a wild population of fruit flies that were trapped randomly on a remote island.

b. "Cross 1, 2, etc."—the phenotypic characteristics of offspring from a controlled cross. The phenotypes of the parents are indicated after each cross—e.g., "Cross 1: Male Ambler × Female Wild Type."

For each of the problems, analyze the results in each cross and answer the questions that follow.

1. Problem One

Wild population	Wild type	Ambler	Total
Male	33	17	50
Female	31	19	50
Total	64	36	100

Cross 1: Male Ambler × Female Wild Type

Offspring Vial 1	Wild type	Ambler	Total
Male	29	24	53
Female	29	31	50
Total	58	55	113

a. What does cross 1 tell you about dominance versus recessiveness of the alleles?

b. What does cross 1 tell you about placement of the alleles on autosomes vs. sex chromosomes?

Cross 2: Female Ambler × Male Wild Type

Offspring Vial 2	Wild type	Ambler	Total
Male	0	32	32
Female	32	0	32
Total	32	32	64

a. What does cross 2 tell you about dominance versus recessiveness of the alleles?

b. What does cross 2 tell you about placement of the alleles on autosomes vs sex chromosomes? (In your answer show the chromosomal genotypes for the parents in this cross.)

2. Problem Two

Mt = Monocle; Bt = Bifocal; Tr =Trifocal; Sp = Spinner; Sh = Shing

Wild Population	Mt, Sp	Mt, Sh	Bt, Sp	Bt, Sh	Tr, Sp	Tr, Sh	Total
Male	10	6	6	0	22	3	47
Female	19	1	9	1	20	4	54
Total	29	7	15	1	42	7	101

Cross 1: Bifocal, Spinner Female × Monocle, Shiny Male

Mt = Monocle; Bt = Bifocal; Tr =Trifocal; Sp = Spinner; Sh = Shing

Offspring Vial 1	Mt, Sp	Mt, Sh	Bt, Sp	Bt, Sh	Tr, Sp	Tr, Sh	Total
Male	0	0	0	0	31	34	65
Female	0	0	0	0	34	38	72
Total	0	0	0	0	65	72	137

a. What does cross 1 tell you about dominance versus recessiveness of the alleles?

b. What does cross 1 tell you about placement of the alleles on autosomes vs. sex chromosomes? (In your answer show the chromosomal genotypes for the parents in this cross.)

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Cross 2: Monocle, Spinner Female × Trifocal, Spinner Male

Mt = Monocle; Bt = Bifocal; Tr =Trifocal; Sp = Spinner; Sh = Shing

Offspring Vial 2	Mt, Sp	Mt, Sh	Bt, Sp	Bt, Sh	Tr, Sp	Tr, Sh	Total
Male	8	8	0	0	8	8	32
Female	23	0	0	0	15	0	38
Total	31	8	0	0	23	8	70

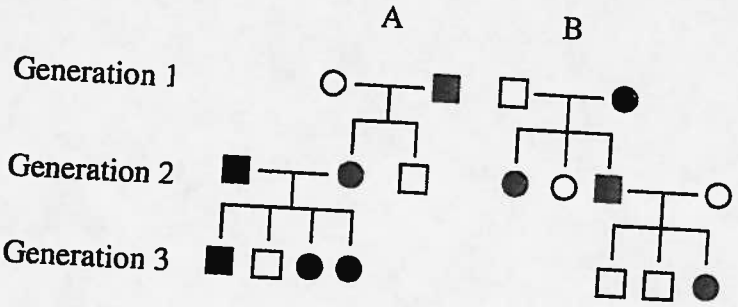
a. What does cross 2 tell you about dominance versus recessiveness of the alleles?

b. What does cross 2 tell you about placement of the alleles on autosomes vs. sex chromosomes? (In your answer show the chromosomal genotypes for the parents in this cross.)

Analysis of Pedigrees

Analyze the pedigree and answer the questions that follow.

The diagram below shows a pedigree of three generations in a family. Black circles/squares indicate persons with a genetic disorder. A square indicates a male and a circle indicates a female. The two males in generation 1 are siblings.



3. Looking only at the generation 2 offspring (of the two generation 1 brothers), what can you say about the gene(s) controlling the genetic disorder? Is the disorder caused by a gene that is dominant or recessive, autosomal or sex-linked?

4. What additional information do you gain from examining the generation 3 offspring?

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Activity 15.3 How can the mode of inheritance be determined experimentally?

Outline the experimental crosses you would need to make to solve each problem.

1. Three new traits have been discovered in a population of *Drosophila*:

   - Tapping (a behavioral mutant in which the fly taps one foot constantly)
   - Single stripe (a pigmentation change that leads to a long stripe down the fly's back)
   - Angular (causes angular bends in bristles that are normally straight)

The positions of the three genes on the chromosomes are unknown. Given two pure breeding (homozygous) lines and using an initial cross of normal, normal, normal females with tapping, single stripe, angular males, describe the appropriate genetic experiments needed to establish whether any of these traits are caused by genes that are:

a. Autosomal or sex-linked

b. Linked on the same chromosome or unlinked

2. A genetics student chose a special project involving a three-gene cross to check the relative positions and map distances separating three genes in *Drosophila* that she thought were all on the third chromosome. To do this, she mated *Drosophila* females that were homozygous for the recessive genes *cu* (curled), *sr* (striped), and *e* (ebony) with males that were homozygous for the wild type, cu^+ (straight), sr^+ (not striped), and e^+ (gray). She then mated (testcrossed) the F_1 females with homozygous recessive curled, striped, ebony males.

Here are the phenotypic results of the testcross:

straight, gray, not striped	820
curled, ebony, striped	810
straight, ebony, striped	100
curled, gray, not striped	97
straight, ebony, not striped	80
curled, gray, striped	90
straight, gray, striped	1
curled, ebony, not striped	2
Total	2,000

a. How are the three genes arranged on the chromosomes?

b. What evidence allows you to answer the question in part a?

c. If any of the genes are linked, how far apart are they on the chromosome? How can you determine this?