Mendel's Laws: Their Application to Solving Genetics Problem

Steps to Solving Genetics Problems

1. READ the problem
2. Write down what you know
3. Assign letters for the alleles (traditionally, you should use the letter of the recessive allele)
    a. Use a capital letter for the dominant trait
    b. Use a lower case letter for the recessive trait
4. Determine the genotypes involved
5. Make gametes (sex cells – each gamete will carry only ONE allele for a trait, not both)
6. Solve using a Punnett Square
7. Reread the question & make sure that you have answered it

Two Trait Problems (Dihybrid Crosses)

SAMPLE PROBLEM: In humans, brown eyes are dominant to blue eyes. Also brown hair (brunette) is dominant to red hair. Imagine that a man who is heterozygous for both traits marries a woman who is heterozygous for both traits.

a. What are the genotypes of the parents?
b. What would be the phenotypic ratio of their potential children?

1. Write down what you know

Parents -	MAN	X	WOMAN
	heterozygous brown eyes		heterozygous brown eyes
	heterozygous brunette		heterozygous brunette

2. Assign letters for the alleles (traditionally, you should use the letter of the recessive allele)
    a. Use a capital letter for the dominant trait
    b. Use a lower case letter for the recessive trait

Since we know that brown eyes is dominant to blue eyes, we will use the letter b for these alleles. Brown is dominant, so it should be B. Blue is recessive, so it should be b.

We know that brunette hair color is dominant to red hair, we will use the letter r for these alleles. Brunette is dominant, so it should be R. Red hair is recessive, so it should be r.

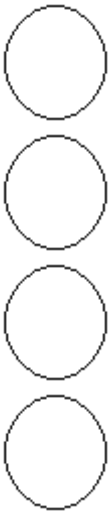
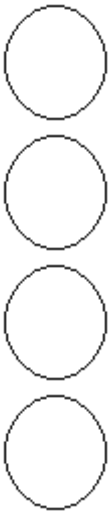
3. Determine the genotypes involved

Remember that the parents are heterozygous for both traits.

Parents -	MAN	X	WOMAN
	heterozygous brown eyes		heterozygous brown eyes
	heterozygous brunette		heterozygous brunette
(Genotypes)	___ ___ ___ ___		___ ___ ___ ___

4. Make gametes (Sex cells – Remember that each gamete will carry only ONE allele for a trait, not both. However, since this is a two-trait or dihybrid problem, the gametes will carry ONE allele for eye color and ONE allele for hair color.)

HINT: Do an allele cross to make sure you get one of every possible type of gamete! (Remember FOIL)

Parents	Man Heterozygous Brown Eyes Heterozygous Brunette	X	Woman Heterozygous Brown Eyes Heterozygous Brunette
(Parent Genotypes)	BbRr		BbRr
Gametes Produced			

5. Solve using a Punnett Square

Gametes				

You have just written all of the genotypes possible for their children! Let's figure out what their phenotypes will be.

a) To have the ***brown eyes, brown hair*** phenotype, a child must have at least B__ R__. There are four ways to satisfy this minimum. Locate each of the following genotypes in the Punnett square and record the number of each type:
BBRR _____ ; BbRR _____ ; BBRr _____ ; BbRr_____ ; Total _____

b) To have the ***brown eyes, red hair*** phenotype, a child must have at least B_rr. Locate and record again:
BBrr _____ ; Bbrr _____ ; Total _____

c) To have the ***blue eyes, brown hair*** phenotype, a child must have at least bbR_. Locate and record again:
bbRR _____ ; bbRr _____ ; Total _____

d) To have the ***blue eyes, red hair*** phenotype, a child must have at least bbrr. Locate and record again:
bbrr _____ ; Total _____

THUS, the phenotypic ratio of the man and woman's potential children is:
_____ brown eyes, brown hair : _____ brown eyes, red hair :
_____ blue eyes, brown hair : _____ blue eyes, red hair

SAMPLE PROBLEM: Imagine that the same man, heterozygous for brown eyes and heterozygous for brown hair, marries a different woman. This woman is heterozygous for brown eyes, **but has red hair**. (Recall that in humans, brown eyes are dominant to blue eyes. Also brown hair (brunette) is dominant to red hair.)

a. What are the genotypes of the parents?
b. What would be the phenotypic ratio of their potential children?

1. Write down what you know

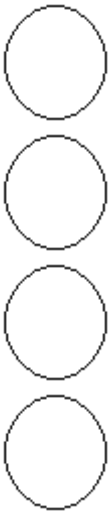
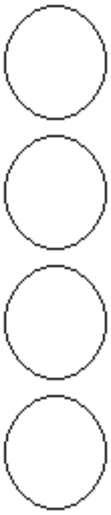
Parents -	MAN	X	WOMAN
	heterozygous brown eyes		heterozygous brown eyes
	heterozygous brunette		red hair

2. Determine the genotypes involved
Remember that the parents are heterozygous for both traits.

Parents -	MAN	X	WOMAN
	heterozygous brown eyes		heterozygous brown eyes
	heterozygous brunette		red hair
(Genotypes)	___ ___ ___ ___		___ ___ ___ ___

4. Make gametes (Sex cells – Remember that each gamete will carry only ONE allele for a trait, not both. However, since this is a two-trait or dihybrid problem, the gametes will carry ONE allele for eye color and ONE allele for hair color.)

HINT: Do an allele cross to make sure you get one of every possible type of gamete! (Remember FOIL)

Parents	Man Heterozygous Brown Eyes Heterozygous Brunette	X	Woman Heterozygous Brown Eyes Red Hair
(Parent Genotypes)	BbRr		Bbrr
Gametes Produced			

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a) To have the ***brown eyes, brown hair*** phenotype, a child must have at least B__ R__. There are four ways to satisfy this minimum. Locate each of the following genotypes in the Punnett square and record the number of each type:
BBRR _____ ; BbRR _____ ; BBRr _____ ; BbRr_____ ; Total _____

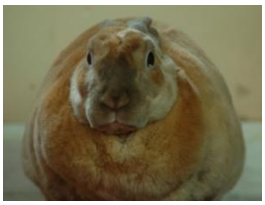
b) To have the ***brown eyes, red hair*** phenotype, a child must have at least B_rr. Locate and record again:
BBrr _____ ; Bbrr _____ ; Total _____

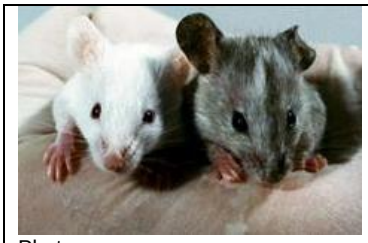
c) To have the ***blue eyes, brown hair*** phenotype, a child must have at least bbR_. Locate and record again:
bbRR _____ ; bbRr _____ ; Total _____

d) To have the ***blue eyes, red hair*** phenotype, a child must have at least bbrr. Locate and record again:
bbrr _____ ; Total _____

THUS, the phenotypic ratio of the man and woman's potential children is:
_____ brown eyes, brown hair : _____ brown eyes, red hair :
_____ blue eyes, brown hair : _____ blue eyes, red hair

SOME PRACTICE DIHYBRID PROBLEMS

Black, long-haired rabbit  Photo source: http://upload.wikimedia.org/	1. In rabbits, black fur is due to a dominant allele B, and brown fur is due to its recessive allele b. Short hair is due to the dominant allele L, & long hair is due to the recessive allele l. A cross is done between a homozygous black, long-haired rabbit & a homozygous brown, short-haired rabbit. What would be the genotype(s) & phenotype(s) of the F_1 generation? When the F_1 offspring are allowed to breed, what will be the phenotypic ratio of the F_2 generation?	Brown, short-haired rabbit  Photo source: http://farm3.static.flickr.com

 Photo source: http://media.knoxnews.com/	2. In mice the gene for coat color has two forms. The allele for colored coat (A) is dominant to the allele for albino (a). There are two forms for the gene controlling whiskers, as well, straight (B) is dominant to bent (b). Imagine that we had a female mouse whose mother was homozygous colored with bent whiskers and whose father was an albino that was homozygous for straight whiskers. We are going to cross this female on a male mouse that is albino and has bent whiskers. a. What percent of their offspring will be albino? b. What percent of their offspring will have straight whiskers? c. What would be the phenotypic ratio of their offspring?

3. In rabbit coats, spotted (S) is dominant to solid color (s) and black (B) is dominant to brown (b). A brown, spotted rabbit is mated with a solid, black one and all the offspring (the F_1 generation) are black and spotted.

a. What are the genotypes of the parents?

b. What are the genotypes of the offspring (the F_1 generation)?

b. What would be the phenotypic ratio of the F_2 generation if two of these F_1 black, spotted rabbits were mated?

White, sphere-shaped squash

Photo source: http://www.thenibble.com/

Yellow, disk-shaped squash

Photo source: http://www.photographsofaustralia.com/

4. In the summer squash, white fruit (Y) is dominant over yellow (y), & disk-fruit shape (S) is dominant over sphere-shaped (s).

For the crosses given below, provide the following in each case:

a. The phenotypes of the parents

b. The phenotypic ratio of the offspring

1) YYss X yySS

2) YySs X yyss

3) YySs X YySs

4) YySs X YySS

Incomplete Dominance Problems

SAMPLE PROBLEM: In humans, inheritance of hair texture shows incomplete dominance. If a person inherits two alleles for curly hair, they have very curly hair (CC). If a person inherits two alleles for straight hair, they have very straight hair (C'C'). A heterozygous person (CC'), on the other hand, shows an intermediate condition, wavy hair. If a wavy-haired man married a wavy-haired woman, what percentage of their children would you expect to have curly hair?

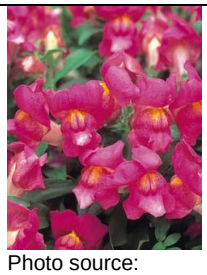
Parents	Man Wavy-Haired	X	Woman Wavy-Haired
(Parent Genotypes)	CC'		CC'
Gametes Produced			

Because the couple are heterozygotes, they will produce two types of gametes; C and C'. We can use this information to complete a Punnett square.

Gametes	C	C'
C		
C'		

What percent of their offspring should have curly hair? _____

SOME PRACTICE INCOMPLETE DOMINANCE PROBLEMS

 Photo source: http://www.greeneartthgrowers.net/	 Photo source: http://www.jparkers.co.uk/	 Photo source: http://www.weststarfarm.com/	1. In snapdragons, red flower color (W) is not completely dominant over white (W'); the heterozygous condition produces pink flowers. What will be the result of a cross between two pink-flowered snapdragons? Between a pink and a white one?

2. Two parents have wavy hair & dimples. They have a child with curly hair & no dimples. Identify the genotypes of the two parents and then determine all of the possible phenotypes that their children could have for the dimple & hair trait. (Remember that dimples is dominant to nondimples. Also the heterozygous condition in which a person inherits an allele for straight hair & an allele for curly hair results in an intermediate condition, wavy hair.)

Red Polled	Roan	White Horned
 Photo source: http://www.rarebreeds.co.nz/	 Photo source: http://www.midcontinentfarms.com/	 Photo source: http://www.glcattleco.com/

3. In shorthorn cattle, the polled (hornless) condition (H) is dominant over the horned condition (h), also the heterozygous condition of red coat (W) and white coat (W') is roan. If a homozygous polled red animal is bred to a white horned one, what will the F_1 be like? If two F_1 were crossed, what would be the phenotypic ratio of the F_2 generation?