HOW TO SOLVE GENETICS "WORD PROBLEMS"

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Frequently, students who have no trouble solving simple genetics problems, have trouble solving "word problems." Several years ago I developed a format to help students work though solving a "word problem." The format has proven to be very helpful. The format involves setting up a chart and filling in the "genetics shorthand" as one reads the question. I also have formats for solving chi square problems, mapping/gene order problems, and cis/trans complementation tests, which are available upon request.

Problem Solving Format:

We are going to go through the format for solving a typical genetics "word" problem. Nearly all genetics problems can be solved using this format. We will start with a simple example and work through it.

Two plants both heterozygous for red flowers are mated to each other. What is the probability of having white flowering offspring? (Note: Red flowers is inherited as a dominant trait.)

The steps are as follows:

1. Read the question.

2. Skim the question for the traits used.
   You should pick the following statements out of the question:
   "both heterozygous for red flowers"
   "red flowers is inherited as a dominant trait"

3. Using the information discovered in your skimming of the question, fill in the following chart:

phenotype	allele	genotype
red	R	RR or Rr
white	r	rr

4. Read the question phrase by phrase, filling in the cross as you read.

"both heterozygous for red flowers"

Rr x Rr

↓

___

5. Calculate how many different gametes can be formed from each parent.
   Rr has 2 kinds of r, therefore,
   Rr can produce 2 types of gametes

6. Write down the possible kinds of gametes.
   In this case the 2 types of gametes are R and r.

7. Check to see if you have already answered the question, you usually do not need to figure the Punnett Square unless the question asks one of the following:
   What is the probability that....
   What are the chances that .....
   What possibilities are there that.....
   or some such similar phrase.
   Our example reads "can you tell what is the probability of".
   Therefore, you must continue.

8. If you need to continue, draw a Punnett Square and fill it in, remember that the gametes from one parent are on the side and the gametes from the other parent are on the top.

	R	r
R		
r		

9. Look at the Punnett Square. Look at each internal square and figure its phenotype. Write down that phenotype, and continue to the next internal square. When you have indicated the total number of each possible phenotype, you have found the probabilities.

RR = red flowers	Rr = red flowers
Rr = red flowers	rr = white flowers

Therefore, 3 red to 1 white or

1/4 would be expected to have white flowers or
25% would be expected to have white flowers or
0.25 would be expected to have white flowers.

Let's try another example using a two trait cross.

A plant heterozygous for long stem (a dominant trait) and homozygous for the recessive trait of terminal flowers is mated to a plant that does not have a long stem and is heterozygous for axial flowers. What is the probability of offspring with axial flowers and a short stem?

The steps are as follows:

1. Read the question.
2. Skim the question for the traits used.
   You should pick the following statements out of the question:
   "a plant heterozygous for long stem"
   long stem is "a dominant trait"
   the plant is also "homozygous for ... terminal flowers"
   terminal flowers is a "recessive trait"
   the other plant "does not have a long stem"
   the other plant is "heterozygous for axial flowers"
3. Using the information discovered in your skimming of the question, fill in the following chart:

phenotype	allele	genotype

Long stem is "a dominant trait."

phenotype	allele	genotype
long stem	L	LL or Ll
short stem	l	ll

Terminal flowers is a "recessive trait."

phenotype	allele	genotype
long stem	L	LL or Ll
short stem	l	ll
axial flowers	A	AA or Aa
terminal flowers	a	aa

4. Read the question phrase by phrase, filling in the cross as you read.

______________ x ____________

↓

___

"a plant heterozygous for long stem"

Ll x _______

↓

___

The plant is also "homozyous for ... terminal flowers."

Llaa x ______

↓

___

The other plant "does not have long stem."

Llaa x ll

↓

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The other plant is "heterozygous for axial flowers"

Llaa x llAa

↓

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5. Calculate how many different gametes can be formed from each parent.
   Llaa has 2 kinds of l, and 1 kind of a, therefore,
   2 x 1 = 2
   Llaa can produce 2 types of gametes.

   llAa has 1 kind of l and 2 kinds of a, therefore,
   1 x 2 = 2
   llAa can produce 2 types of gametes.

6. Write down the possible kinds of gametes
   The 2 types of gametes from Llaa are La and la.
   The 2 types of gametes from llAa are lA and la.

7. Check to see if you have already answered the question, you usually do not need to figure the Punnett Square unless the question asks one of the following:
   What is the probability that....
   What are the chances that .....
   What possibilities are there that.....
   or some such similar phrase.
   Our example reads "what is the probability that".
   Therefore, you must continue.

8. If you need to continue, draw a Punnett Square and fill it in, remember that the gametes from one parent are on the side and the gametes from the other parent are on the top.

	La	la
lA	LlAa	llAa
la	Llaa	llaa

9. Look at the Punnett Square. Look at each internal square and figure its phenotype. Write down that phenotype, and continue to the next internal square. When you have indicated the total number of each possible phenotype, you have found the probabilities.

LlAa	= long stem and axial flowers	1/4
llAa	= short stem and axial flowers	1/4
Llaa	= long stem and terminal flowers	1/4
llaa	= short stem and terminal flowers	1/4

The question asked "What is the probability of offspring with axial flowers and a short stem? "

1/4 would be expected to have axial flowers and short stem.

25% would be expected to have axial flowers and short stem.

HOW TO SOLVE CHI-SQUARE PROBLEMS

Chi-Square = sum of the $(\text{observed-expected})^2$ / expected
The problem is usually figuring out the expected.
To find the expected:

1. Do a Punnett Square.

2. Use the ratios from the Punnet Square. Put the ratios in the form of a fraction or decimal.
   For example, 9:3:3:1 is actually 9/16, 3/16, 3/16, and 1/16.

3. Multiply each fraction by the total number observed.

Example:		
	916 tall, red	9/16 x 1621 = expected
	325 tall, white	3/16 x 1621 = expected
	295 short, red	3/16 x 1621 = expected
	<u>85 short, white</u>	1/16 x 1621 = expected
	1621 total	

4. Fill in the following chart:

Observed	Expected	(o-e)	$(o\text{-}e)^2$	$(o\text{-}e)^2$ / e	
Example:					
916	912	916-921 = 4	$4^2 = 16$	16/912 =	0.018
325	304	325-304 = 21	$21^2 = 441$	441/304 =	1.451
295	304	295-304 = 9	$9^2 = 81$	81/304 =	0.266
<u>85</u>	<u>101</u>	85-101 = 16	$16^2 = 256$	256/101 =	<u>2.535</u>
1621	1621				4.270

5. Now look up 4.27 on a probability table that lists the critical values of a Chi-Square distribution. Remember that the degrees of freedom are one less than the number of classes (4 - 1 = 3).