TWO PAIRS OF GENES: DIHYBRID CROSS:

Mendel's Law of Independent Assortment refers to the behavior of two or more pairs of alleles which are carried on different pairs of chromosomes. During meiosis each pair of chromosomes separates into different gametes independently of other pairs. The result is that the gametes contain all possible combinations of the genes constituting the different pairs. [Linked genes are a partial exception to this law.]

Let us consider two different pairs of traits simultaneously. Once again we start out with true-breeding strains.

P_1 yellow, round seed x green, wrinkled seed
GG WW gg ww
|
F_1 100% (yellow round)
Gg Ww
|

Key: G - yellow
g - green
W - round
w - wrinkled

F_2	315	yellow round	G _ W _
	101	yellow wrinkled	G _ ww
	108	green round	gg W _
	32	green wrinkled	gg ww
	556		

We can calculate the expected results using either a Punnett square or algebra. [There are other methods as well.]

The F_1 produce 4 kinds of gametes:

(1/2 G + 1/2 g)(1/2 W + 1/2 w) = 1/4 GW + 1/4 Gw + 1/4 gW + 1/4 gw)

These gametes are placed along the side and also across the top of the Punnett square.

♀/♂	1/4 GW	1/4 G w	1/4 g W	1/4 g w
1/4 GW	1/16 GG WW	1/16 GG Ww	1/16 Gg WW	1/16 Gg Ww
1/4 G w	1/16 GG Ww	1/16 GG ww	1/16 Gg Ww	1/16 Gg ww
1/4 g W	1/16 Gg WW	1/16 Gg Ww	1/16 gg WW	1/16 gg Ww
1/4 g w	1/16 Gg Ww	1/16 Gg ww	1/16 gg Ww	1/16 gg ww

Thus in the Punnett square, we are multiplying the gametes of the female by the gametes of the male:

[(1/2 G + 1/2 g)(1/2 W + 1/2 w)][(1/2 G + 1/2 g)(1/2 W + 1/2 w)] =
(1/4 GW + 1/4 Gw + 1/4 gW + 1/4 gw)(1/4 GW + 1/4 Gw + 1/4 gW + 1/4 gw)

If we are doing algebra, we rearrange the equations:

(1/2 G + 1/2 g)(1/2 G + 1/2 g)(1/2 W + 1/2 w)(1/2 W + 1/2 w) =
(1/4 GG + 2/4Gg + 1/4 gg)(1/4 WW + 2/4Ww + 1/4 ww) =

Expected F_2 genotypic ratios:	Phenotype
1 GG WW	yellow round
2 GG Ww	yellow round
1 GG ww	yellow wrinkled
2 Gg WW	yellow round
4 Gg Ww	yellow round
2 Gg ww	yellow wrinkled
1 gg WW	green round
2 gg Ww	green round
1 gg ww	green wrinkled
16	

These are the same results summarized from both the Punnett square and from the algebraic expansion. The Punnett square is both too slow and increases the opportunity for errors to occur. You will need to learn to use the algebraic method.

We may now summarize the expected genotypic and phenotypic ratios as:

genotypic ratio	phenotypic ratio
9 G _ W _	yellow round
3 G _ ww	yellow wrinkled
3 gg W _	green round
1 gg ww	green wrinkled
16	

Note that if we examine the algebraic expressions, we see that if we consider only the G's and forget about the W's, our expected genotypic ratio is still (1 GG: 2 Gg: 1 gg), and our expected phenotypic ratio is still 3/4 yellow: 1/4 green. Likewise, if we consider only the W's and forget about the G's, our expected genotypic ratio is still (1 WW: 2 Ww: 1 ww), and our expected phenotypic ratio is still 3/4 round: 1/4 wrinkled.

Therefore, by combining probabilities, we can again calculate an expected frequency of green round as (1/4 green)(3/4 round) = 3/16.

How good were Mendel's results? (How closely did his observed data agree with his expected results?) We can calculate what his expected results should be by the following:

observed			expected
315	yellow round	G _ W _	(9/16)(556) = 312.75
101	yellow wrinkled	G _ ww	(3/16)(556) = 104.25
108	green round	gg W _	(3/16)(556) = 104.25
32	green wrinkled	gg ww	(1/16)(556) = 34.75
556			556.00

Note the extremely close agreement.

The "**branching method**" of doing a cross is simply diagramming the algebra Thus, if you were to self an GgWw plant, you would do the algebra within each gene pair, and then multiply their products together.

(1/2 G + 1/2 g)(1/2 G + 1/2 g)(1/2 W + 1/2 w)(1/2 W + 1/2 w) =
(1/4 GG + 2/4 Gg + 1/4 gg)(1/4 WW + 2/4 Ww + 1/4 ww) =