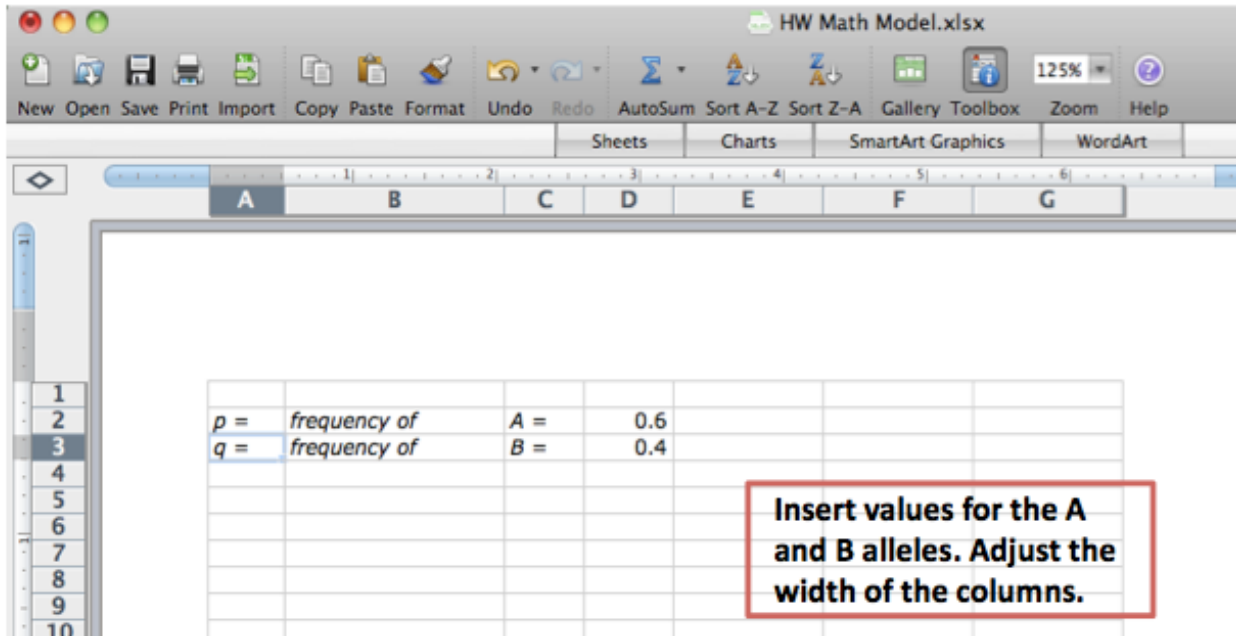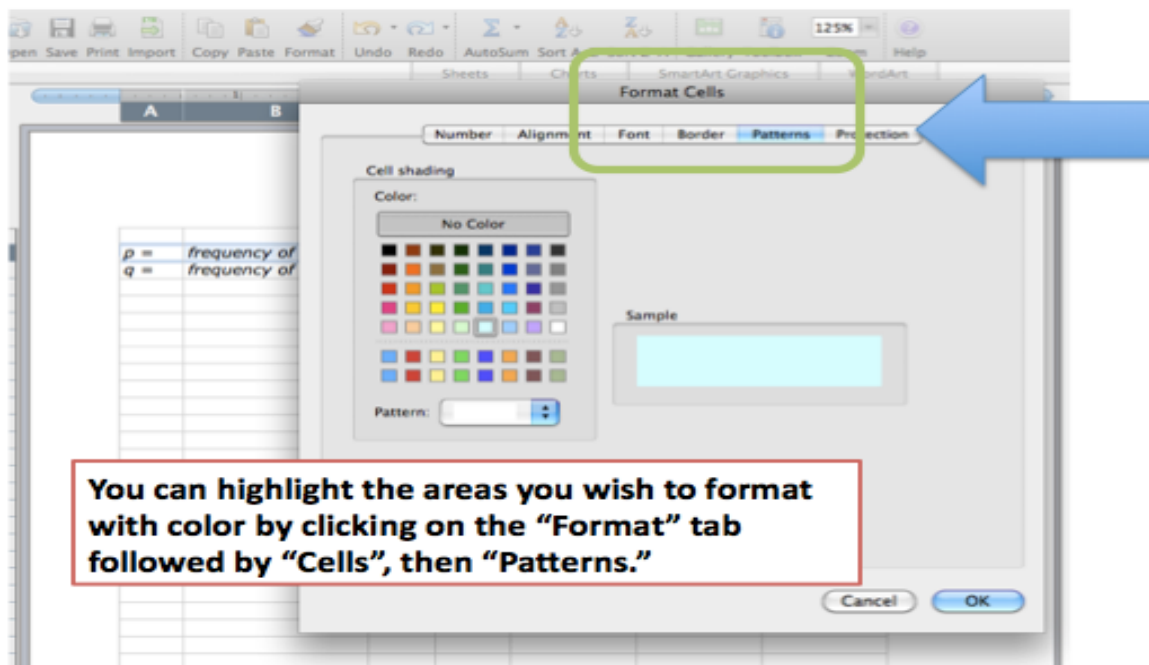## Using Excel to Model H-W

How can mathematical models be used to investigate the relationship between the allele frequencies in populations of organisms and evolutionary change?

Next step is to highlight the area you wish to format with color. Note: This is an *optional* step.

Using Excel to Model H-W

In a nearby empty cell, enter the
function **+Rand()**
It will be removed later. Hit return.
What do you find in the cell?

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6	
q =	frequency of	B =	0.4	
				=+RAND()

Notice what happens. If you are using a PC, try hitting the F9 key several times to force recalculation. On a Mac, enter *cmd +* or *cmd =*. What happens to the value in the cell?

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6	
q =	frequency of	B =	0.4	
				0.1489519

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6	
q =	frequency of	B =	0.4	
				0.2660449

The RAND function returns random numbers between 0 and 1 in decimal format. By using this function, this model is simulates the "random" choosing of gametes from a gene pool.

Go ahead and delete the RAND function in the cell. Select two gametes from the gene pool. In cell E5, you need to generate a random number, compare it to the value of *p*, and then place either an *A* gamete or a *B* gamete in the cell. To do this, you will need two functions – the RAND function and the IF function.

Click on the E5 cell, then go to the "Insert" tab. Click on "Function," and type in the following function:
=IF(RAND()<=D$2, "A", "B")
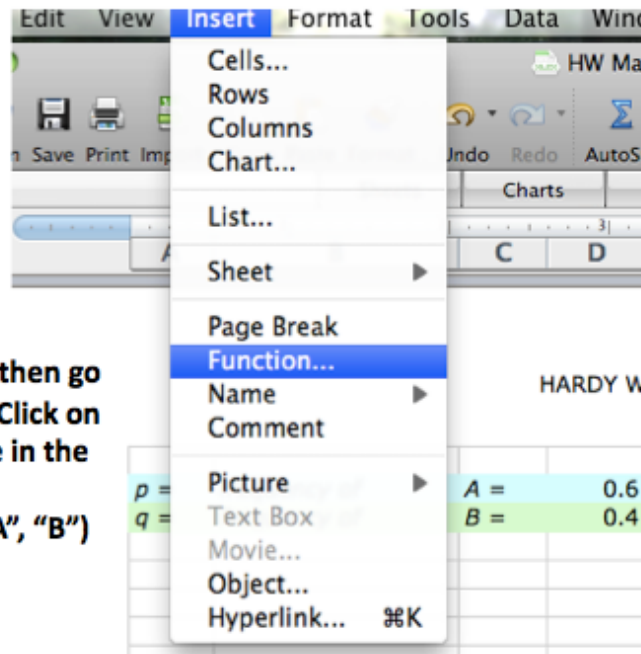
The formula basically says that if a random number between 0 and 1 is less than or equal the value of *p*, then put an *A* gamete in this cell, or if it is NOT less than or equal to the value of *p*, then put a *B* gamete in this cell.

Your spreadsheet should look like this:

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6	
q =	frequency of	B =	0.4	
			gametes	
			B	A

Try recalculating 10-20 times. This is what will happen.

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6		
q =	frequency of	B =	0.4		
				gametes	
				B	A

HARDY WEINBERG MODEL

p =	frequency of	A =	0.6		
q =	frequency of	B =	0.4		
				gametes	
				B	B

Try changing your *p* value to 0.8 or 0.9. Does the spreadsheet still work as expected? Try some lower *p* values.

Copy these 2 formulas in E5 and F5 down for about 16 rows to represent gametes that will form 16 offspring for the next generation. To copy the formulas, click on the bottom right-hand corner of the cell and, with your finger pressed down on the mouse, drag the cell downward.

HARDY WEINBERG MODEL

It should
look like
this.

p =	frequency of	A =	0.6		
q =	frequency of	B =	0.4		
				gametes	
				B	B
				A	B
				A	B
				B	B
				B	B
				A	B
				A	B
				A	B
				B	B
				A	B
				A	B
				A	B
				B	B
				A	B
				A	B
				A	B
				A	B
				A	B
				B	B
				B	B

You will put the zygotes in cell G5. In cell G5 enter the function =CONCATENATE(E5,F5)
and then copy this formula down as far as you have gametes.
It should look like this.

p =	frequency of	A =	0.6			
q =	frequency of	B =	0.4			
				gametes		
				A	B	AB
				A	B	AB
				A	B	AB
				B	B	BB
				A	B	AB
				A	B	AB
				A	B	AB
				A	B	AB
				A	B	AB
				A	B	AB
				A	B	AB
				B	B	BB
				A	B	AB
				A	B	AB
				B	B	BB
				B	B	BB
				A	B	AB
				B	B	BB
				A	B	AB
				A	B	AB

The next columns on the spreadsheet are H, I, and J. These are "housekeeping" columns.
They keep track of the numbers of each zygote's genotype. You will enter the following
functions for each column.
The function in cell H is =IF(G5="AA",1,0).

The function in cell J is =IF(G5="BB",1,0)

In cell I5, enter this function: =IF(G5="AB",1,(IF(G5="BA",1,0))).

Enter the labels for the columns you have been working on. Cell E4 *gametes*, Cell G5 *AA* in cell H4, and *BB* in Cell J4. It should look like this:
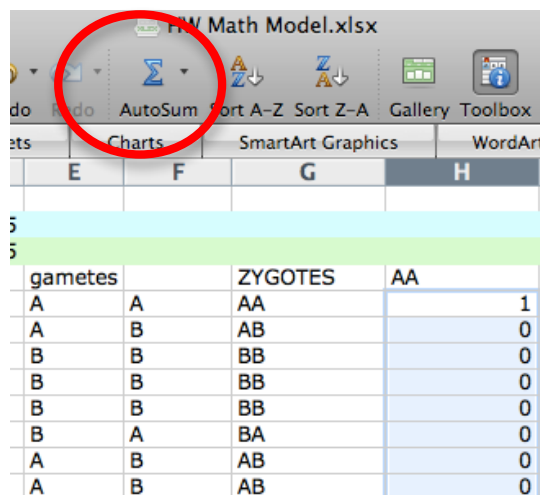
frequency of	A =	0.6							
frequency of	B =	0.4							
				gametes			ZYGOTES	AA	AB	BB
				A	B		AB	#NAME?	#NAME?	#NAME?
				B	B		BB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				B	B		BB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				A	B		AB			
				B	B		BB			
				B	B		BB			
				A	B		AB			
				B	B		BB			
				A	B		AB			
				B	B		BB			
				A	B		AB			

Try recalculating a number of times to make sure everything is working as expected. Don't go on until you are sure the spreadsheet is making correct calculations. Try different values for *p*. Make sure the number of zygotes adds up.

Copy the cells E5 through J5 down as many zygotes as you would like in the first generation. It should look like this:

A	B	C	D	E	F	G	H	I	J
p =	frequency of	A =	0.5						
q =	frequency of	B =	0.5						
				gametes		ZYGOTES	AA	AB	BB
				A	A	AA	1	0	0
				A	B	AB	0	0	1
				B	B	BB	0	1	0
				B	B	BB	0	1	0
				B	B	BB	0	1	0
				B	A	BA	0	0	1
				B	B	BB	0	1	0
				A	B	AB	0	0	1
				A	A	AA	1	0	0
				B	B	BB	0	1	0
				B	B	BB	0	1	0
				B	A	BA	0	0	1
				A	B	AB	0	0	1
				B	B	BB	0	1	0
				A	A	AA	1	0	0
				B	B	BB	0	1	0
				B	A	BA	0	0	1
				A	B	AB	0	0	1
				B	B	BB	0	1	0
				B	B	BB	0	1	0

Use the SUM function to calculate the numbers of each genotype in the H, I, and J columns. To do this, highlight the numbers in the column and press the "AutoSum" button. It should look like this:

p =	frequency of	A =	0.5							
q =	frequency of	B =	0.5							
				gametes		ZYGOTES	AA	AB	BB	
				A	A	AA	1	0	0	
				A	B	AB	0	0	1	
				A	B	AB	0	0	1	
				B	B	BB	0	1	0	
				A	B	AB	0	0	1	
				B	A	BA	0	0	1	
				B	B	BB	0	1	0	
				A	B	AB	0	0	1	
				B	A	AA	1	0	0	
				A	B	AB	0	0	1	
				A	B	AB	0	0	1	
				B	A	BA	0	0	1	
				B	B	BB	0	1	0	
				A	B	AB	0	0	1	
				B	A	BA	0	0	1	
				A	B	AB	0	0	1	
				A	A	AA	1	0	0	
				A	B	AB	0	0	1	
				A	B	AB	0	0	1	
				B	B	BB	0	1	0	
							3	4	13	

Make a bar graph of the genotypes using the chart tool. Your graph should resemble this. All you need to do is add the title and label the X and Y axes.
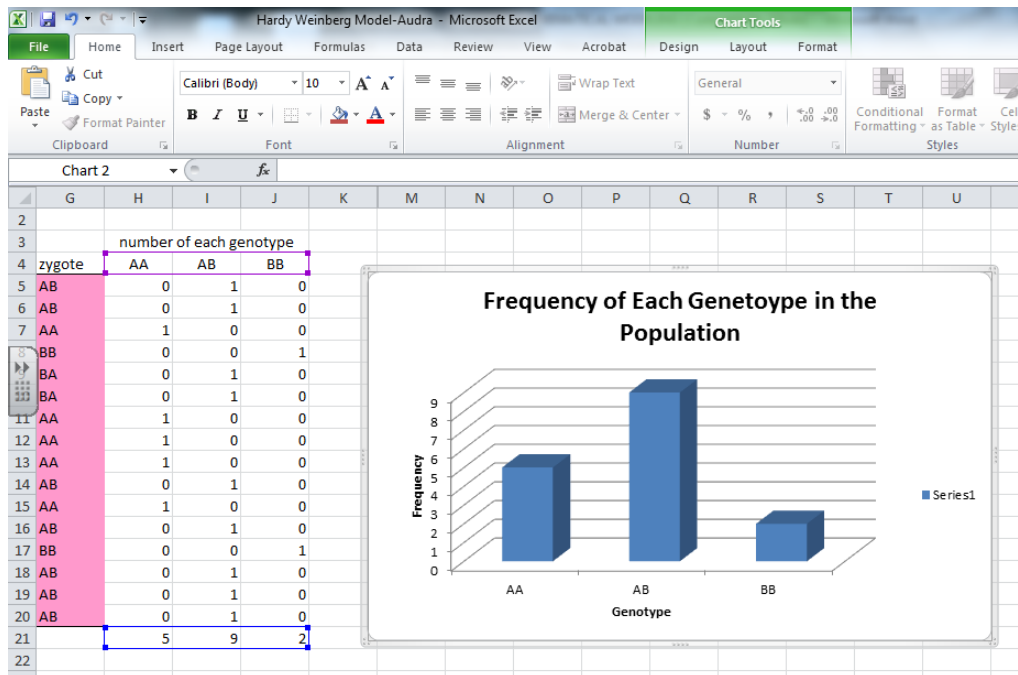
To calculate the number of each allele, A and B, the formulas are:

- for cell H24:   =COUNTIF(E5:F20, "A")

- for cell J24:   =COUNTIF(E5:F20, "B")

This counts the number of A alleles and the number of B alleles in columns E and F.

19				B	A	BA	0	1	0
20				A	A	AA	1	0	0
21		sums for each genotype					5	10	1
22									
23							A		B
24		number of each allele					20		12
25									
26							p		q
27		allele frequency next generation					0.625		0.375

To calculate the allele frequencies of the next generation, cells H27, and J27, use the following formulas:

- for cell H27: =H24/(H24+J24)

- for cell J27: =J24/(H24+J24)

	B	C	D	E	F	G	H	I	J	K
17				B	A	BA	0	1	0	
18				A	A	AA	1	0	0	
19				B	A	BA	0	1	0	
20				A	A	AA	1	0	0	
21	sums for each genotype						7	8	1	
22										
23							A		B	
24	number of each allele						22		10	
25										
26							p		q	
27	allele frequency next generation						0.6875		0.3125	