

Fruit Fly Tutorial 1

This tutorial is designed to illustrate how to analyze genetics data using the StarGenetics software tool.

Learning Objectives

After completing this tutorial, you will be able to:

1. Perform genetics experiments in the genetics cross simulator, StarGenetics.
2. Identify the phenotype of a fruit fly within StarGenetics.
3. Determine whether a phenotype is dominant or recessive relative to another phenotype through the analysis of results from genetic crosses.
4. Determine whether an allele is autosomal or sex-linked through the analysis of results from genetic crosses.

Getting started with StarGenetics

- To get to StarGenetics, please navigate to: <http://star.mit.edu/genetics>.
- Click on the **Start** button to launch the application.
- Click **Trust** when a prompt appears asking if you trust the certificate.
- Click on **File → New** on the main menu.
- Click on the **StarGenetics Tutorial 1** file.

When you first open this tutorial, you will see one mutant fly, called **Mutant 1**, and two wild type flies (female and male) within the **Strains** box.

1 What is the sex of the mutant fly?

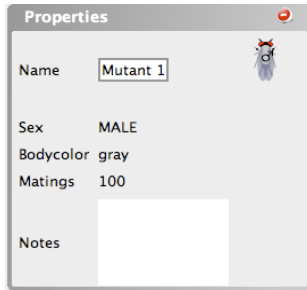
Let's take a closer look at the mutant fly and compare it with one of the wild-type flies.



The sex symbol is indicated within the body of each fly. For example, the wild type, indicated above, is female and the mutant fly is male (see sex symbol legend above).

2 What is the phenotype of the mutant fly?

Wild-type flies have red eyes, brown bodies and full size antennae and wings. If you compare the color and features of the wild-type and Mutant 1 fly, you will see that both have red eyes, full size antennae and wings. The one exception is body color. Mutant 1's body color is grey instead of brown (wild-type body color). You can also obtain the same information by clicking on the fly and looking at the **Properties** window. The characteristics that differ from wild type are indicated within the **Properties** box as well as some other relevant information (sex, number of matings, etc).

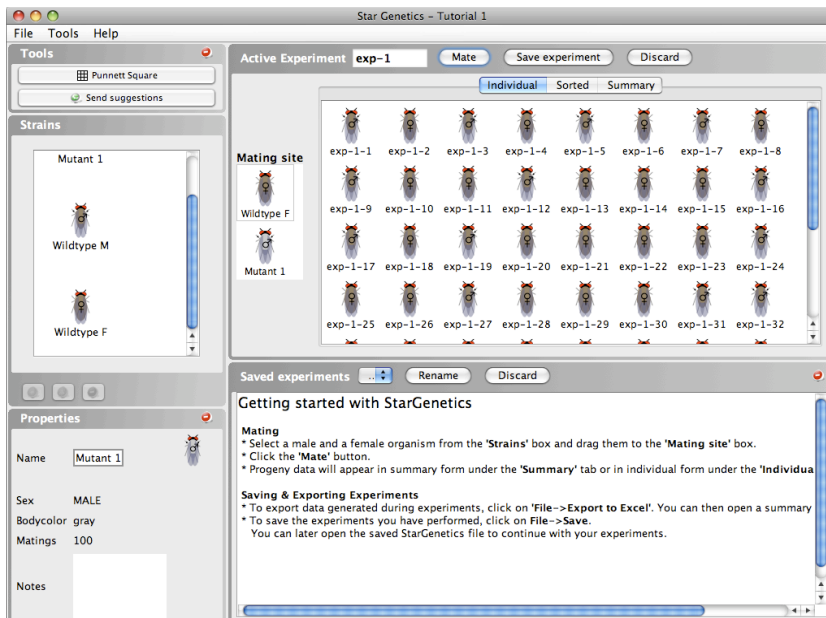


3 Next, we will address whether the allele that confers Mutant 1's grey body color is recessive or dominant.

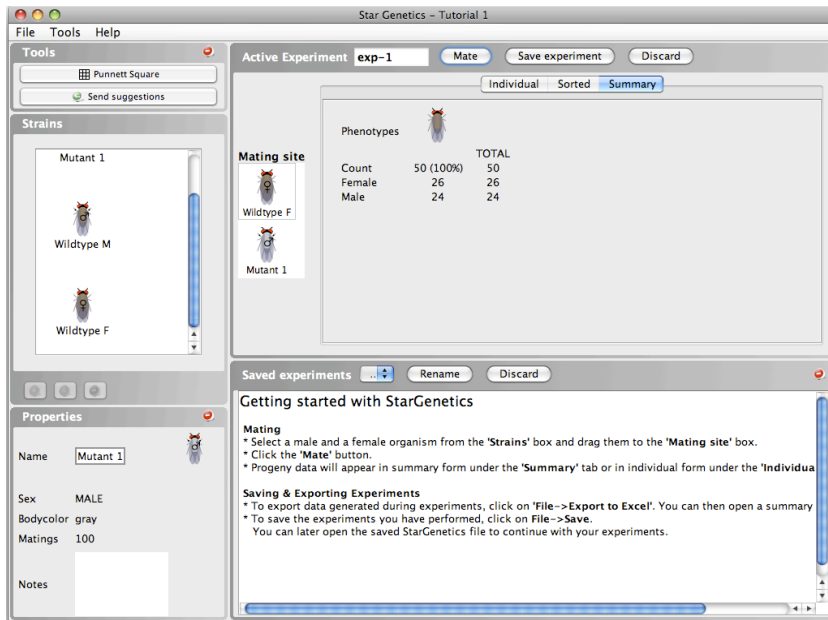
The easiest way to answer this question is to mate the mutant fly in question, Mutant 1, with a wild-type fly. Let's set up this mating:

- Drag both the Mutant 1 and the female wild type fly into the **Mating site**.
- Click on the **Mate** button.

a) What results do you obtain?



You can see all the flies resulting from this cross within the **Individual** tab or you can see a summary of the experiment by clicking on the **Summary** tab.



Within the **Summary** tab all the organisms are organized by phenotypes.

b) How many phenotypes do you see?

Only one phenotype is present in the F1 progeny. This phenotype resembles the wild-type parent.

Phenotypes		
Count	50 (100%)	TOTAL 50
Female	26	26
Male	24	24

You can see that there are a total of 50 progeny: 21 female and 29 male flies.

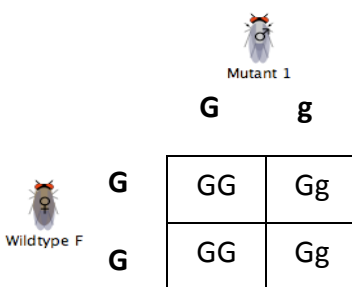
c) What do these results tell you about the gray body color allele?

If all the flies have the phenotype of the wild-type parent, then this means that the gray body color allele is recessive to wild type. Can we always assume that?

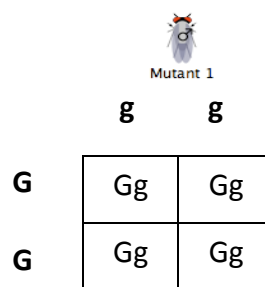
Let's take a closer look...

- what kind of results would you expect if Mutant 1 was heterozygous for the gray body color allele?
- what kind of results would you expect if Mutant 1 was homozygous for the gray body color allele?

If Mutant 1 is heterozygous



If Mutant 1 is homozygous



Expected genotypic ratio:

2 GG : 2 Gg

Expected phenotypic ratio:

All wild type

Expected genotypic ratio:

All Gg

Expected phenotypic ratio:

All wild type

Regardless of whether the genotype of Mutant 1 is heterozygous or homozygous for the gray body allele, the resulting progeny when crossed to a wild-type fly is wild type.

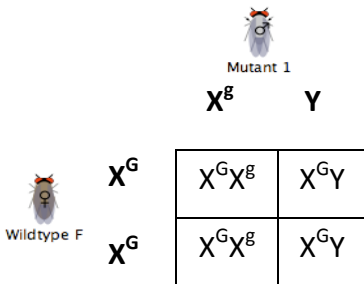
Note: this type of cross cannot differentiate between these two possible genotypes for Mutant 1. To do that, we will need to perform another cross.

4 We will now address whether the allele that confers Mutant 1's grey body color is autosomal or X-linked.

From the first cross, it seems like the grey body color allele might be autosomal. However, from this one cross it is not possible to make this conclusion.

a) Can a sex-linked grey body allele lead to the results obtained in our first cross?

Since we know that the grey body color is recessive, we can discern that if the allele is sex-linked, then the genotype would be as follows:



Expected genotypic ratio:



2 $X^G X^g$: 2 $X^G Y$

Expected phenotypic ratio:

All female and male progeny would be wild type

The hallmark of a X-linked allele is differential partitioning of the allele in female versus males, since males only carry one copy of each allele. To determine if this is the case, we will need to perform one of the two possible informative crosses.

POSSIBLE CROSS 1: One possible cross is an F1 female to an F1 male. These are the results we obtain when we perform this cross:

Phenotypes			TOTAL
Count	10 (20%)	40 (80%)	50
Female	0	22	22
Male	10	18	28

We observe a 1:4 ratio of gray body flies to wild-type flies. All the gray body flies are male. This differential partitioning of the gray body color allele indicates that the gray body color gene is X-linked. Here is the Punnett Square for this cross (F1 female X F1 male) if we assume that the gray body color allele is X-linked.

	X^G	Y	
X^G	$X^G X^G$	$X^G Y$	F1 male: $X^G Y$ F1 female: $X^G X^g$
X^g	$X^G X^g$	$X^g Y$	

Expected genotypic ratio:

1 $X^G X^G$: 1 $X^G X^g$: 1 $X^G Y$: 1 $X^g Y$

Expected phenotypic ratio:

3 wild type: 1 gray body color

All females are wild type; 1:1 ratio of gray body male flies to wild-type male flies.

The ratio of wild type to gray body flies we observe with 50 F2 flies is 4:1 and not 3:1 as predicted, respectively. An increase in the number of progeny from 50 to 300 reveals a ratio that is closer to 3:1. Using larger data sets is always preferable to increase the statistical significance of your conclusions!

Phenotypes			TOTAL
Count	71 (23%)	229 (76%)	300
Female	0	142	142
Male	71	87	158

As previously predicted and observed when we performed this experiment with 50 F2 flies, half of the male flies have gray bodies and half of them have wild-type body color. Together these results indicate that the gray body color gene is X-linked.

POSSIBLE CROSS 2: Mating two F1 flies is not the only possible cross we could have used to test whether the gray body gene is autosomal or X-linked. The mating of a F1 female to one of the original wild-type male parents will also provide the necessary information to discern between autosomal or X-linkage mode of inheritance.

	X^G	Y	
X^G	$X^G X^G$	$X^G Y$	Wild-type male (provided in the Strains box): $X^G Y$ F1 female: $X^G X^g$
X^g	$X^G X^g$	$X^g Y$	

Expected genotypic ratio:



1 X^GX^G : 1 X^GX^g : 1 X^gY : 1 X^GY

Expected phenotypic ratio:

3:1 ratio of wild type to gray body color

All females are wild type; 1:1 ratio of wild type to gray body color ratio for male flies.

The results we obtain match our expected results:

Phenotypes			
Count	69 (23%)	231 (77%)	TOTAL 300
Female	0	157	157
Male	69	74	143

Therefore, either crossing a F1 female to a F1 male or crossing a F1 female to the original wild-type male will lead you to the same conclusion: the gray body color gene is X-linked.

Your approach to performing the crosses for this type of genetic analysis is up to you. The important steps are 1) to evaluate your initial experimental results, 2) to construct a hypothesis that can explain your results (in this case by using Punnett Square analysis), and then 3) to test your hypothesis by performing additional experiments.

Hope you enjoyed this tutorial!