Mendelian Genetics Using *Drosophila melanogaster*

Biology 12, Investigation 1

Learning the rules of inheritance is at the core of all biologists training. These rules allow geneticists to predict the patterns of trait expression in animals and plants, they allow doctors to predict the probabilities of many genetic disorders, and they help evolutionary biologists to understand how many traits have and will evolve.

For the next 2-3 weeks, you will be investigating the rules of inheritance using the model organism for most animal-based genetics --- the fruit fly, *Drosophila melanogaster*. First, you will conduct crosses using live fruit flies. Second, you will use the computer-based “Virtual FlyLab” to conduct artificial crosses that will elucidate the rules of inheritance patterns for many traits. Third, you will collect data (progeny) over the next 3 weeks and use their phenotypes to test if patterns of Mendelian inheritance are demonstrated by the offspring of your initial crosses.

**Before you come to lab:** Review Punnett Squares; purchase *A Short Guide to Writing about Biology* by Pechenik

**Week 1**

**Experimental objective:** to set up laboratory crosses of Drosophila to test hypotheses of inheritance.

**When you leave lab you should be able to:** Predict the results of this experiment if your trait is dominant or recessive and sex-linked or not.

**Writing objectives:** Structure of the hypothesis; overview of scientific paper

**Writing HW:** Read Chapter 1 and 8 in Pechenik and answer associated questions.

1. **Crosses with live Drosophila**

   Working in pairs, cross flies of different phenotypes. Your Teaching Fellow will provide specific instructions on how to perform these crosses.

2. **Instructions for out-of-class data**

   Beginning at day 10, and twice a week thereafter for the next 3 weeks, you will need to check on the offspring of your flies. On each day in which you census your lab colony, record the following information:

   1) the number of males and females
   2) the phenotype of each fly

   Your data sheet should look something like this:
### Investigation 1

#### Individual Traits

<table>
<thead>
<tr>
<th>Individual</th>
<th>sex</th>
<th>eye color</th>
<th>wing shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>m</td>
<td>red</td>
<td>normal</td>
</tr>
<tr>
<td>2</td>
<td>f</td>
<td>white</td>
<td>normal</td>
</tr>
<tr>
<td>3</td>
<td>m</td>
<td>white</td>
<td>normal</td>
</tr>
<tr>
<td>4</td>
<td>m</td>
<td>red</td>
<td>normal</td>
</tr>
<tr>
<td>5</td>
<td>m</td>
<td>red</td>
<td>normal</td>
</tr>
<tr>
<td>6</td>
<td>m</td>
<td>red</td>
<td>normal</td>
</tr>
<tr>
<td>7</td>
<td>f</td>
<td>white</td>
<td>normal</td>
</tr>
<tr>
<td>8</td>
<td>f</td>
<td>white</td>
<td>normal</td>
</tr>
<tr>
<td>9</td>
<td>f</td>
<td>white</td>
<td>normal</td>
</tr>
</tbody>
</table>

**OR,** you can simply make column headings and use “chicken scratches” to tally up numbers in each column. For example:

<table>
<thead>
<tr>
<th>Sex</th>
<th>Eye Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>White</td>
</tr>
<tr>
<td>male</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td></td>
</tr>
</tbody>
</table>

After the first generation of adult flies has eclosed (between days 10-20), determine if the inheritance patterns of eye color and wing shape. Does your hypothesis change after the second generation of flies has eclosed and been counted?

### 3. In-class assignment: Using Punnett Squares to make predictions

Often scientists design an experiment to test a particular hypothesis, or idea about how nature might work. If the hypothesis is true, one set of results is expected. If, however, an alternate hypothesis is true another set of results is expected.

In this experiment your task is to determine the pattern of inheritance for a particular trait in *D. melanogaster*. This trait might be dominant or recessive relative to the wild type. And, it might be sex-linked or not. Your initial hypotheses to test might be:

- The trait is dominant and not sex-linked.
- The trait is recessive and not sex-linked.
- The trait is dominant and sex-linked.
- The trait is recessive and sex-linked.
But, you can’t really test these “hypotheses” because they do not make a prediction. Therefore we need to reframe our hypotheses. If we write:

If the trait is dominant and sex-linked, then we expect…
we will have a testable prediction. Then we can compare our results to the predictions of each hypothesis and evaluate the competing ideas.

Remember that you will know the phenotype but not the genotype of your parental fruit flies. Therefore, you will need to work out the Punnett Squares for each possible combination of genotypes.

1. Suppose the trait is dominant and not sex-linked. Draw Punnett Squares for reciprocal crosses in both the F1 and F2 generations.

2. Suppose the trait is recessive and not sex-linked. Draw Punnett Squares for reciprocal crosses in both the F1 and F2 generations.

3. Suppose the trait is dominant and sex-linked. Draw Punnett Squares for reciprocal crosses in both the F1 and F2 generations.

4. Suppose the trait is recessive and sex-linked. Draw Punnett Squares for reciprocal crosses in both the F1 and F2 generations.
Now, fill in the following chart with your predictions.

<table>
<thead>
<tr>
<th><strong>Hypothesis</strong></th>
<th><strong>F1 predictions</strong></th>
<th><strong>F2 predictions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The trait is dominant and not sex-linked.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The trait is recessive and not sex-linked.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The trait is dominant and sex-linked.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The trait is recessive and sex-linked.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now, you are ready to write testable hypotheses in the “If…then…” format. Complete the following.

1. If the trait is dominant and not sex-linked then

2. If the trait is recessive and not sex-linked then

3. If the trait is dominant and sex-linked then

4. If the trait is recessive and sex-linked then

Note: Not all hypotheses follow this format explicitly. The important point here is that your hypothesis is an idea about how nature works that makes a testable prediction. Here, you hypothesize that if your trait is dominant then all the F1 offspring will display the phenotype associated with your trait. You can conduct an experiment and monitor the offspring phenotype as a means to assess your hypothesis.

1. Read Chapter 1, “Introduction and General Rules.” Twenty five tips are listed, pick the five that you think you need to work on the most and list them here. These will be your starting goals for the semester. You will return to these periodically to evaluate your progress and set new goals.

The following questions are based on Chapter 8. Although these questions are based on what we consider to be the highlights, you are expected to study the entire chapter.

2. Why does Pechenik recommend starting by writing the Materials and Methods section rather than the Abstract?

3. Pechenik writes, “Begin [writing the Materials and Methods section] by listing all the factors that might have influenced your results. Imagine that you are going to write a scientific paper about the Drosophila experiment you began in the first week of class.
   a. List all the factors that might influence your results
   b. List at least three details that would not influence your results and that therefore should not be included in a scientific paper on this topic

4. Carefully study “A Model Materials and Methods Section.” List at least three features that make this an excellent model.
5. Why does Pechenik argue that the Results section is the most important section of a scientific paper?

6. Pechenik lists two tricks for organizing data, what are they?

7. Study the sample table. Where is the caption?

8. Study figure 15. List the five features of a good figure.

9. Why is Table 6 better than Table 7?

10. List the three questions a self-sufficient table or graph answers.

11. In what order should you present your tables and graphs?

12. Pechenik states in bold, “You must use words to draw the reader’s attention to the key patterns in your data.” A poor example and two good examples are listed. What is the problem with the first example?
13. What are some strengths of the second two examples?

14. Why should results be presented in the past tense?

15. If you use the word “significant” in scientific writing, what does it imply?

16. Why must your expectations be backed up with a reference?

17. Carefully read the section entitled, “Explaining Unexpected Results.” In your own words, explain what Pechenik means when he writes, “Always be careful to distinguish possibility from fact.” Why is this point especially important in the Discussion?

18. What must you explain in the Introduction?

19. Examples of “In this study…” statements are given. What distinguishes the strong from the weak examples?

20. What is the difference between a study and an experiment?

21. List Pechenik’s five general rules for providing background.


22. What must be summarized in the Abstract?

**Week 2**

**Experiment:** Monitoring reciprocal crosses to determine the pattern of inheritance of vestigial wings and red eyes in *Drosophila melanogaster*.

**When you leave lab you should be able to:** Explain the procedure for this experiment including when and why you will remove the parents and set up new crosses.

**In-class exercise:** Using the Virtual Fly Lab to test hypotheses regarding patterns of inheritance for traits in *D. melanogaster*.

**Writing objectives:** Structure of the Materials and Methods section

**Writing HW:** Revise your Materials and Methods section

**1. In-class exercise: “Virtual FlyLab”!**

Virtual FlyLab allows you play the role of a research geneticist. It is an educational application for learning the principles of genetic inheritance. You design matings between female and male fruit flies carrying one or more genetic mutations. After selecting the mutations for the two parent flies and clicking the "Mate" button, you will be returned a document containing the images of the parent and offspring flies. Virtual FlyLab will apply the correct rules of genetic inheritance to these mutations to obtain the offspring. It is your job to determine these rules based on the "experimental" results.

Traits are organized into groups such as "bristles" and "body colors." Within each group a trait can be specified for either the male or the female. If one of the parents has a mutation, then the other parent must be wild type. Virtual FlyLab restricts you to selecting one mutation from each group. (These are software restrictions, not ones imposed by nature!)

**There are two steps:**

1. Use the radio buttons to choose a combination of genetic traits for the parent flies. Wild type is the default, which represents a fly that is normal for that trait.
2. Click the button labelled "Mate Flies" to perform the cross.

**IMPORTANT! You need to know the following rules in order to analyze your crosses:**

If no mutation within a group is selected, both flies will be homozygous for the wild type alleles for all the mutations within that group.

If you select a mutation and the mutation is not lethal, the male or female fly is made homozygous for the selected mutation. All the other traits within that group will be homozygous for the wild type allele.

If you select a mutation within a group and the mutation is lethal, the fly is made heterozygous for that mutation. (A homozygous fly would be dead!)

If you select two lethal mutations which are in the same linkage group, then the mutant alleles will be placed on different homologous chromosomes; this is called the "trans" arrangement.

If you select three or more lethal mutations in the same linkage group, Virtual FlyLab will divide the alleles as evenly as possible between the two homologous chromosomes.

It is best to focus on one or two traits at a time; otherwise things can get very complicated. In fact, if you choose too many traits at the same time, you may get an error message. This is because the number of different offspring combinations that would be produced could be very large and it would be impractical to return that many flies. Remember, the goal is to learn something about the rules of genetic inheritance!
**In-class Assignment:**

**Using Virtual FlyLab,** discover the patterns of inheritance for 3 traits (your choice).

Hand in to your Teaching Fellow, the traits you explored and the following information:

- 1) Name of the trait (mutation).
- 2) Is the trait (mutation) dominant or recessive?
- 3) Is the trait (mutation) sex-linked?
- 4) Is the trait (mutation) lethal?
- 5) Is the trait (mutation) linked to any others?

Provide a detailed description of the crosses you performed and your results that allowed you to determine the answers to each of these questions for **one of the traits.**

**2. Homework assignment: Writing a Materials and Methods section**

a) We will begin with a list of questions designed to help you prepare to write the Materials and Methods section. Keep the general format of these questions in mind when you write future papers.

1. List all the factors that might influence your results.

2. What facts about your study organism should be included?

3. Why did you set up a reciprocal cross?

4. Why did you need to set up an F2 cross?

5. How will you analyze your data?
b) Draft the Materials and Methods section. You may do this electronically or on a sheet of scrap paper. We will discuss examples in class.

When you think you have a pretty good draft, turn to page 212 in Pechenik. Use the checklist to edit your draft.

**Weeks 3-4: Creating F2 crosses**

Once you have adult F1 flies from your crosses and have scored them for their phenotypes, you will need to set up F2 crosses. Your teaching fellow will instruct you on how to do this. As before, you will need to periodically census the offspring from these crosses. Beginning at day 10, and twice a week thereafter for the next 3 weeks, you will need to check on the offspring of your flies. On each day in which you census your lab colony, record the following information:

1) the number of males and females
2) the phenotype of each fly

**Week 7-8: Analyzing the results**

From the results of your crosses with live Drosophila, provide all data in the form outlined above to your Teaching Fellow. Your TF will then provide you with the cumulative data from the class as a whole. From these data, determine the answers to the following questions:

- 1) Name of the trait (mutation).
- 2) Is the trait (mutation) dominant or recessive?
- 3) Is the trait (mutation) sex-linked?
- 4) Is the trait (mutation) lethal?