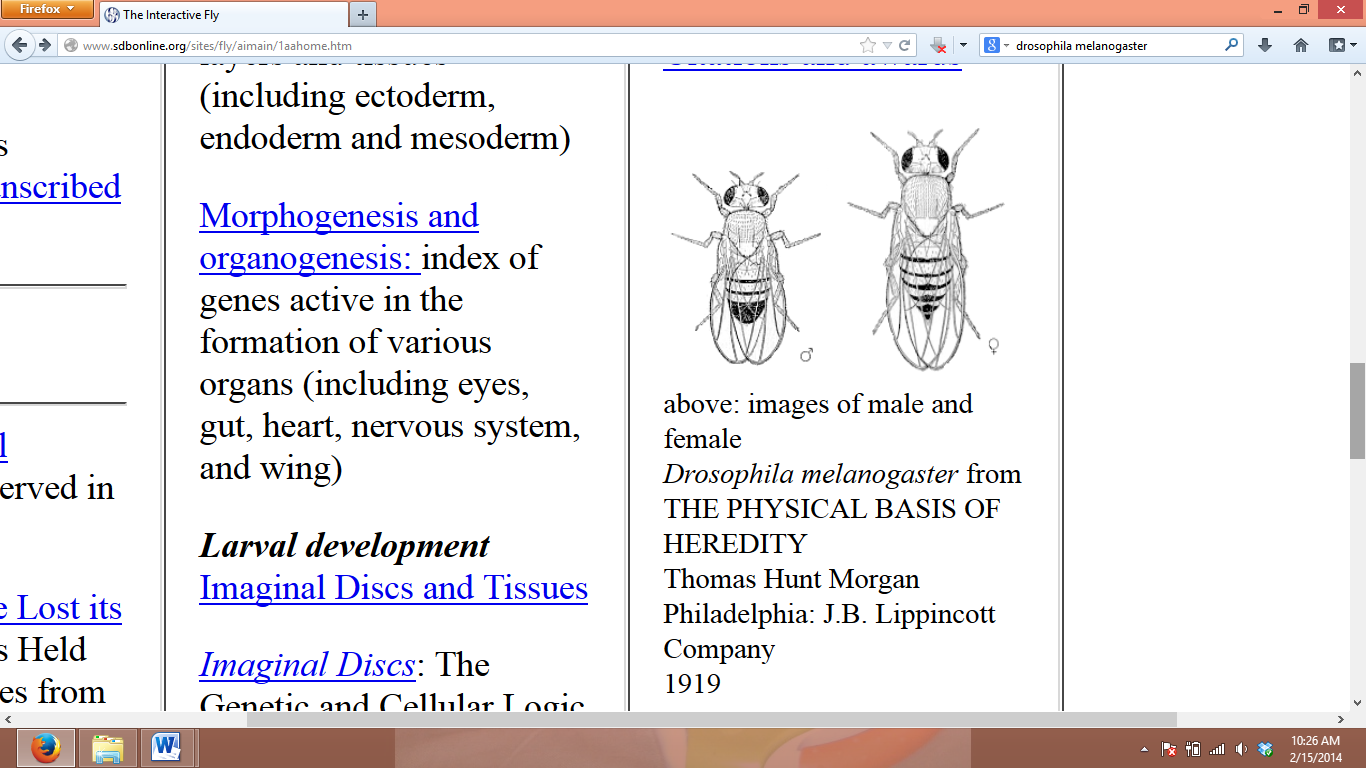
FLYLAB

*An Investigation of Heredity in* Drosophila melanogaster.



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**FlyDay 1**

Notes Outline: Introducing the Fruit Fly *Drosophila melanogaster*

Classifying Drosophila

|  |  |  |
| --- | --- | --- |
| **Taxonomic Level** | **Group** | **Characteristics** |
| Domain | Eukaryota | Cells have nuclei |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| Family |  | “Drosopholidae” = “drosophila-like |
| SCIENTIFIC NAME (genus, species) | *Drosophila melanogaster* | n/a |

Life Cycle – similar to most insects

1. \_\_\_\_\_\_\_\_\_\_\_\_\_ 2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ 3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (both terms)

**Ecology:**

Geographic distribution: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Energy source / ecological role: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Model Organisms:**

Some characteristics that make *Drosophila* good “model” organisms:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What does “prodigious” mean? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Drosophila genetics**:

Chromosomes: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Sex chromosomes: pair # \_\_\_\_, versions: \_\_\_\_\_\_\_\_

**Basic breeding terminology:**

Male: \_\_\_\_\_ Female: \_\_\_\_\_\_

Generations: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

“wild type” traits: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mutant traits: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**FlyDay 2**

Selection of P Generation Flies

**Introduction**: Fruit flies have been studied extensively by biologists, and research with them has lead to many important discoveries. In this lab, you will selectively mate flies in order to determine how characteristics are passed from one generation to another.

**Goal**: Determine how the inheritance of eye color in *Drosophila melanogaster* is different from the inheritance of wings, by using laboratory data to support classifying each as an example of autosomal dominance, incomplete dominance, codominance, or sex linkage.

**Materials & Methods**

Part I: The first cross

1. Collect data about the characteristics of the flies you may select to mate in Data table I. Choose two that you would like to mate to see their offspring. Be sure to select one female and one male fly from your set. Write down the characteristics of the flies you select to mate in the “select your first cross” section.

*Fruit fly characteristics*

A certain characteristic (for example red eye color) is called a ***phenotype*** in biology. For example, for the trait “eye color,” phenotypes include “red” and “white.” In fruit flies, the characteristics found most commonly in natural populations are referred to as “wild type.” Red is the wild-type eye color phenotype and winged is the wild-type wing phenotype.

To determine the sex of a fruit fly, examine its abdomen. Males have a distinctive black spot at the tip, whereas females do not. When selecting flies to cross, make sure you include one of each sex!

**Data**

Table 1: Initial parent phenotypes: Flies available to mate (characteristics)

|  |  |  |  |
| --- | --- | --- | --- |
| Wing phenotype (wild type or apterous) | Eye color phenotype (wild type or white) | Sex (M or F) | Number of flies |
|  |  |  |  |
|  |  |  |  |
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|  |  |  |  |

**Select your First Cross**: NOTE: If you select two flies that have different phenotypes for wings **and** eye color (e.g. red eyes & wingless x white eyes & wings) be prepared for some difficult, confusing results!!!

**Male**: Eye color: \_\_\_\_\_\_\_\_\_\_\_ Wings: \_\_\_\_\_\_\_\_\_\_\_ x **Female**: Eye color: \_\_\_\_\_\_\_\_\_\_\_ Wings: \_\_\_\_\_\_\_\_\_\_\_\_

**Hypothesis**

What do you expect the offspring from your first cross to be like? Will they all have a certain characteristic? Will they have some mixture of the parent’s characteristics? Or will some of the offspring flies have different characteristics from others? Why do you think that?

The offspring flies will \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Prediction**: If \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Then \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Analysis**

1. Why do you think the offspring of the first cross will be the way you do? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. What is your second-best guess about what the first set of offspring might look like, and WHY?

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3. List ANY three phenotypes you personally have

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**FLYDAY 3**

Observing the F1 generation and selecting your F1 cross

**Data**:

Phenotypes of P generation flies: male: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ female: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

F1 offspring:

|  |  |  |  |
| --- | --- | --- | --- |
| Wing phenotype (wild type or apterous) | Eye color phenotype (wild type or white) | Sex (M or F) | Number of flies |
|  |  |  |  |
|  |  |  |  |
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**Analysis** of the F1 data:

1. Were the results what you expected? Explain how your F1 data supports or does not support your hypothesis from part I.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. Write a hypothesis that states which phenotypes you think are dominant, and why:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. It may or may not be possible at this time for you to construct a Punnett square that accurately describes the P generation cross you selected, depending on what data you have collected. Make your best effort to do so; it does not necessarily have to be correct. And remember – since these aren’t real flies, the data are 100% accurate, so the ratios among different phenotypes are all exactly as they should be.

4. Did you notice any evidence that certain phenotypes were more common in males or females? If so, what did you observe, and how could this be explained?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Did any other groups mate flies with the same phenotypes you did? Complete the class data review and analysis on the separate sheet you were provided.

**Selection of F1 flies to mate**

Select male and female flies from the F1 generation to mate. Try to select flies that will provide the most information to help you solve this puzzle

F1 male to mate (phenotypes) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ F1 female to mate (phenotypes) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Prediction**: Reread the hypothesis you wrote above (#2), and then write a prediction that clearly states **what you expect the F2 generation of flies to be like** if your hypothesis is accurate.

IF \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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THEN \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**FlyDay 4**

Observing the F2 Generation and Selecting Your Final Cross

**Data**:

Phenotypes of F1 generation flies mated: male: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ female: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Hypotheses: COMPLETE BEFORE ANALYZING F2 DATA!!!**

Possible genotypes of F1 generation flies mated: male: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ female: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Data**:

F2 offspring:

|  |  |  |  |
| --- | --- | --- | --- |
| Wing phenotype (wild type or apterous) | Eye color phenotype (wild type or white) | Sex (M or F) | Number of flies |
|  |  |  |  |
|  |  |  |  |
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**Phenotype Ratios:**

Eye color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Wings: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Analysis** of the F2 data:

1. Were the results what you expected? Explain how your F2 data supports or does not support your hypothesis from part II.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. Write a hypothesis that states which phenotypes you think are dominant, and why. If required, review the class data to check your thinking.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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3. Now, FIGURE IT OUT!!! At this time, you should be able to produce Punnett squares illustrating monohybrid crosses (i.e. one trait per Punnett square) that accurately describe the F1 cross you just analyzed the offspring from. These Punnett squares should accurately account for all of the observed F2 data you have just received. Draw all Punnett squares that describe your F1 cross and the F2 offspring.

**Selection of F2 flies to mate**

Select male and female flies from the F2 generation to mate. Now, you should be able to select flies that will produce offspring you will be able to predict. Perhaps you could do a testcross to determine if an individual with a dominant phenotype is homozygous or heterozygous for that trait. **The results of this F2 cross should confirm what you have discovered already**. This is the final cross you will investigate.

F2 male to mate (phenotypes) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ F2 female to mate (phenotypes) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Prediction**:

Draw all Punnett squares that could represent the POSSIBLE genotypes of the F2 flies you have selected to cross. When you receive the F3 data, you should be able to determine which of these possible squares actually represents the F2 fly genotypes. In other words, when you get the F3 data, you should be able to determine the genotypes of your F2 parents from these squares.

**FlyDay 5**

The Final Chapter: Data Analysis & Conclusions

**Data**:

Phenotypes of F2 generation flies mated: male: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ female: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Hypotheses: COMPLETE BEFORE ANALYZING F3 DATA!!!**

Possible genotypes of F2 generation flies mated: male: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ female: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Data**:

F3 offspring:

|  |  |  |  |
| --- | --- | --- | --- |
| Wing phenotype (wild type or apterous) | Eye color phenotype (wild type or white) | Sex (M or F) | Number of flies |
|  |  |  |  |
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**Phenotype Ratios:**

Eye color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Wings: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Analysis** of the F3 data:

1. Were the results what you expected? Explain how your F3 data supports or does not support your hypothesis from part III.

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2. Write a hypothesis that states which phenotypes you think are dominant, and why. If required, review the class data to check your thinking.

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3. Now, FIGURE IT OUT!!! Draw a Punnett square representing the F2 cross you just received the results of.

**Analysis: Pedigree & Punnett Squares**

Draw a pedigree illustrating the inheritance you have observed in flies that includes all of the data you have received, from the P generation to the F3. If you are analyzing BOTH eye color and wings, you will have to construct two separate pedigrees. Include in your pedigrees all of the genotypes you can determine. THIS IS THE THOROUGH DESCRIPTION OF EVERYTHING YOU HAVE FIGURED OUT. Complete these pedigrees on a separate sheet of paper.

Punnett Squares: Construct 3 Punnett squares, one for the P generation cross, one for the F1 cross, and one for the F2 cross that describe the offspring produced. If studying two traits, use a dihybrid square (Ingenuity or Honors) or two monohybrid squares (Honors).

**CONCLUSION**: In the format of one or more paragraphs, describe what you have discovered. This should include:

* **The type of inheritance displayed for each trait you have studied** (e.g. complete dominance, incomplete dominance, codominance, sex-linkage, or multiple alleles). IF ALL OF YOUR FLIES HAVE THE SAME PHENOTYPE FOR A CERTAIN TRAIT, IGNORE THAT TRAIT. For example, if all of your flies have the same eye color, don’t attempt to explain the inheritance of eye color!
* **Specific evidence that supports your conclusion about how each trait is inherited.** This evidence should be specific crosses that support your conclusion. These crosses can be crosses you conducted or you found in the class data.
* **What alleles control the traits, and what is dominant**.
* **Specific evidence that supports that conclusion about what alleles are dominant and recessive.** Use data from crosses you have conducted or found in the class data.

DUE DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**FlyDay 6**

Communication of Findings

**Introduction**: The last step in any cycle of scientific investigation is the presentation and discussion of findings with peers investigating similar topics. The purpose of these discussions is to share knowledge and thinking with clarity and respect, and to challenge assertions that are not supported by data. In this way, groups of scientists reach consensus – a shared understanding about what is understood to be true about a certain phenomenon.

**Seminar Procedure**:

Format:

* Each team will have one representative in the active discussion circle at any time.
* An observing team member may “tap out” the active member and take their place when desired.
* It is expected that **every student will speak** about their findings or the findings of another team.

Process:

1. **Opening Statements**: Each team will have an opportunity to present their findings briefly (1-2 minutes). This should describe the two claims (pattern of inheritance and alleles present) as well as the evidence supporting them and the reasoning that explains how the evidence supports the claims. Participants are encouraged to make reference to Punnett squares, pedigrees, or other data they have analyzed to reach their conclusions. When not speaking, **it is highly encouraged that you make notes** about what other teams say, as you will be expected to ask questions about their findings.
2. **Discussion of findings**: After each team has presented their initial statements, a more open discussion will begin. Speakers may ask clarifying questions, add to statements other teams have made, or challenge unsound claims, evidence or reasoning in a respectful way.
3. **Construction of consensus**: Having heard the various claims, evidence, and reasoning supplied by research teams, I will facilitate the construction of a consensus by determining what has been established by independent verification, and we will conclude by deciding on conventions for naming alleles, writing them, and formatting data for potential future investigations.

Evaluation:

* Team members will be **evaluated individually** using the class discussion rubric below.

Other Information:

* + It is expected that participants will adhere to the norms, respect the rights, and fulfil the obligations for productive discussions described below.
  + Make strategic use of the “science sentence starters” below if you find yourself struggling to form a relevant statement.

**Norms, Rights, and Obligations for a Productive Discussion**

**Norms for Productive Discussion:**

* Everyone has a chance to participate.
* Everyone feels that they will be respected.
* Everyone can hear what is said and who is talking

**Participant Rights:**

* You have the right to ask questions.
* You have the right to be treated respectfully.
* You have the right to have your ideas discussed, not you personally.
* You have the right to be listened to carefully, and to be taken seriously by your colleagues.

**Participant Obligations:**

* You have a responsibility to speak loud enough for others to hear.
* You have an obligation to answer questions seriously.
* If you cannot hear or understand what someone says, you have a responsibility to ask them to repeat or explain.
* You have an obligation to treat others with respect.
* You will be called on to discuss other people’s ideas, to agree or disagree, and to explain your reasoning.

**Seminar Participation Rubric**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **5** | **4** | **3** | **2** | **1** |
| **Quality of Comments** | Timely and appropriate comments, thoughtful and reflective, responds respectfully to other student's remarks, provokes questions and comments from the group | Volunteers comments, most are appropriate and reflect some thoughtfulness, leads to other questions or remarks from student and/or others | Volunteers comments but lacks depth, may or may not lead to other questions from students | Struggles but participates, occasionally offers a comment when directly questioned, may simply restate questions or points previously raised, may add nothing new to the discussion or provoke no responses or question | Does not participate and/or only makes negative or disruptive remarks, comments are inappropriate or off topic |
| **Resource/ Document Reference** | Clear reference to text being discussed and connects to it to other text or reference points from previous readings and discussions | Has done the reading with some thoroughness, may lack some detail or critical insight | Has done the reading; lacks thoroughness of understanding or insight | Has not read the entire text and cannot sustain any reference to it in the course of discussion | Unable to refer to text for evidence or support of remarks |
| **Active Listening** | Posture, demeanor and behavior clearly demonstrate respect  and attentiveness to others | Listens to others most of the time, does not stay focused on other's comments (too busy formulating own) or loses continuity of discussion. Shows consistency in responding to the comments of others | Listens to others some of the time, does not stay focused on other's comments (too busy formulating own) or loses continuity of discussion. Shows some consistency in responding to the comments of others | Drifts in and out of discussion, listening to some remarks while clearly missing or ignoring others | Disrespectful of others when they are speaking; behavior indicates total non-involvement with group or discussion |

**Science Sentence Starters**

**For All Discussions:**

I wonder \_\_\_\_\_\_\_\_

I want to add to what \_\_\_\_ just said about \_\_\_\_\_

To your point about \_\_\_\_ I would add/say \_\_\_\_\_\_

One additional thing about \_\_\_\_\_\_ is \_\_\_\_\_\_\_\_

To build on what \_\_\_\_\_\_ said, \_\_\_\_\_\_

Going back to what \_\_\_\_\_ said, \_\_\_\_\_

I agree with \_\_\_\_\_\_\_ because \_\_\_\_\_\_\_\_

I disagree with \_\_\_\_\_\_ because \_\_\_\_\_\_\_

To clarify, \_\_\_\_\_\_\_\_\_\_\_

I know from \_\_\_\_\_\_\_\_ that \_\_\_\_\_\_, so \_\_\_\_\_\_\_\_

**For Reading Discussions:**

The text is about \_\_\_\_\_

The text is organized \_\_\_\_\_

On page/in paragraph \_\_\_\_\_, the article \_\_\_\_\_\_\_\_\_\_

Based on the article, \_\_\_\_\_\_\_

On page/in paragraph \_\_\_\_\_, I noticed \_\_\_\_\_, and/so I think \_\_\_\_\_\_\_\_

What I read about \_\_\_\_\_\_\_\_ made me think \_\_\_\_\_\_\_\_\_\_

I thought something different than \_\_\_\_\_\_ when I read \_\_\_\_\_\_\_, because \_\_\_\_\_\_\_\_

**For Investigative Discussions:**

What does not make sense to me is \_\_\_\_\_\_

What I don’t understand is why \_\_\_\_\_\_\_

What we don’t know is \_\_\_\_\_\_\_\_

What is the evidence that \_\_\_\_\_\_\_\_\_

I think \_\_\_\_\_\_\_\_\_, because I saw/heard/felt/smelled/tasted/measured \_\_\_\_\_\_\_

Because I saw/heard/felt/smelled/tasted/measured \_\_\_\_\_\_\_, I think \_\_\_\_\_\_\_\_\_

Based on the \_\_\_\_\_\_\_ data, I think \_\_\_\_\_\_

The data about \_\_\_\_\_\_\_ makes me think \_\_\_\_\_\_

The \_\_\_\_\_ data shows \_\_\_\_\_\_

I noticed/saw \_\_\_\_\_ and this made me think \_\_\_\_\_\_

If we knew/tested \_\_\_\_\_\_ then \_\_\_\_\_\_

\_\_\_\_\_\_\_\_ happened/occurred because of \_\_\_\_\_\_\_\_

What would happen if \_\_\_\_\_\_\_\_

I wish we could \_\_\_\_\_\_\_\_

Maybe we could/should \_\_\_\_\_\_\_