**How Can Sex-Linked Traits Be Identified?**

**I. Introduction**

Sex-linked traits are characteristics carried on genes of the sex chromosomes. Thomas Hunt Morgan was one of the first scientists known to observe sex linkage. In his experiments with the common fruit fly, Drosophila melanogaster, he analyzed the results of the following *Drosophila* mating:

1. A white-eyed male crossed with a red-eyed female produced all red-eyed F1 offspring, as expected according to Mendelian laws of inheritance. An F1 red-eyed male crossed with an F1 red-eyed female would result in 3 red-eyed F2 offspring (male or female): 1 white-eyed F2 offspring (male or female) according to Mendelian laws of inheritance. But Morgan found that all of the F2 female offspring and half of the F2 male offspring had red eyes, which is not expected according to Mendelian laws of inheritance.

A white-eyed female crossed with a red-eyed male resulted in all of the F1 female offspring having red eyes and all of the F1 male offspring having white eyes, which is expected according to Mendelian laws of inheritance. An F1 red-eyed female crossed with an F1 white-eyed male would result in 3 red-eyed F2 offspring (male or female): 1 white-eyed F2 offspring (male or female) according to Mendelian laws of inheritance. But Morgan found that half of the F1 offspring of each sex had red eyes and the other half had white eyes, which is not expected according to Mendelian laws of inheritance.

2. Morgan's results proved that more complex laws of inheritance exist. The alleles for Drosophila eye-color are not simply dominant or recessive. Because of the ratios that resulted from his Drosophila crosses, Morgan concluded that the gene for eye color is carried by, or linked to, the X chromosome. He also found that the Y chromosome does not carry a gene for this characteristic.

Fruit flies are often used to study genetics because of their short life cycle (about 2 weeks), their small size (several hundred can be housed in a small jar), and their fecundity (a single pair may produce more than a hundred offspring).

English biologist Reginald Punnett developed a simple method for finding the expected proportions of genotypes and phenotypes in the offspring of a genetic cross. It is called a Punnett square. Punnett squares can be used to predict the traits of offspring in genetic crosses. When using Punnett squares to analyze the results of crosses involving eye-color in Drosophila, XR represents the dominant allele for red-eye color and Xr represents the recessive allele for white-eye color.

The purpose of this Investigation is to explore the sex-linked gene for eye color in *Drosophila*. This will involve performing various fruit-fly mating involving the eye-color trait and analyzing the outcomes of the mating using Punnett Squares.

**II. Procedure**

1. Start the activity by going to the following website :

<http://glencoe.mheducation.com/sites/dl/free/0078802849/383935/BL_15.html> .

2. Click the TV/VCR. Then, click the “Play” button on the video controller. Watch the video

about *Drosophila* mating.

3. On the Biology Laboratory Navigation Screen, click the vials to mate *Drosophila* in the

laboratory or click the notebook to perform genetic crosses using Punnett Squares.

4. *Drosophila* Mating : Examine the four vials that contain pure lines of Supply *Drosophila.*

There is fruit-fly medium (food) in the bottom of the test tubes. Each test tube is labeled with

a magnified drawing of the type of fly that is in that test tube. Use the key at the bottom, of

the rack of vials to differentiate between male *Drosophila* and female *Drosophila.*

5. Decide which flies to mate for the P Generation Cross. Click one of the four vials of Supply

*Drosophila* and drag a fly to the P Generation Cross vial. A picture of the selected fruit fly

will appear on the label of the P Generation Cross vial. Click and drag another fruit fly to the

P Generation Cross vial. You may change your selection by clicking and dragging the fly

back to its Supply *Drosophila* vial.

6. Click the “Mate & Sort” button next to the P Generation Cross Vial.

If no mating takes place, check the sexes of the two flies that you selected to cross and try

again.

If a mating takes place, many offspring result. The offspring sort into the F1 Generation

vials. The number of each type of offspring will appear next to the picture of the fruit fly

on the label of the vial. Record your data in the Table.

7. Decide which flies to mate for the F1 Generation Cross. Click one of the four F1 Generation

vials and drag a fly to the F1 Generation Cross vial. A picture of the selected fruit fly appears

on the label of the F1 Generation Cross vial. Click and drag another fruit fly to the F1

Generation Cross vial. You may change your selection by clicking and dragging the fly back

to its F1 Generation vial. NOTE : The number of offspring on the label of a F1 Generation

vial will change if you drag a fly out of that vial.

8. Click the “Mate & Sort” button next to the F1 Generation Cross vial.

If no mating takes place, check the sexes of the two flies that you selected to cross and try

again.

If a mating takes place, many offspring result. The offspring sort into the F1 Generation

vials. The number of each type of offspring will appear next to the picture of the fruit fly

on the label of the vial. Record your data in the Table.

9. Click the “Return” button to save your data and return to the Biology Laboratory Navigation

Screen. Or, click the “Reset” button to erase your data and start over.

10. After mating *Drosophila* in the laboratory and performing genetic crosses using Punnett

Squares, answer the questions.

11. Punnett Square : Label the Punnett square by clicking the arrow under the male parent and

the female parent and selecting parents to cross. The alleles of the selected parents appear

next to each box of the Punnett Square.

12. Determine the genotype and phenotype of the offspring that result from the genetic cross.

Fill in the Punnett square by clicking and dragging the appropriate offspring at the bottom of

the Punnett Square to the appropriate boxes in the Punnett square. If you want to change

your selection, you must first drag the offspring that you want to change out of the box and

drag your new selection to the empty box.

13. Click the “Check” button.

If a box in the Punnett Square is filled in incorrectly, that box will be highlighted. Drag

out the incorrect selection. Examine the parents’ alleles and try again.

If the Punnett Square is filled in correctly, the phenotype and genotype ratios appear.

Use this data to answer the questions.

14. Click the “Return” button to save your data and return to the Biology Laboratory Navigation

Screen, or click the “Reset” button to erase your data and start over.

**III. Data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Phenotype**  **Male**  **Parent** | **Phenotype**  **Female**  **Parent** | **# Red-Eyed**  **Male**  **Offspring** | **# White-Eyed**  **Male**  **Offspring** | **# Red-Eyed**  **Female**  **Offspring** | **# White-Eyed**  **Female**  **Offspring** |
| P  Generation  Cross |  |  |  |  |  |  |
| F1  Generation  Cross |  |  |  |  |  |  |
| P  Generation  Cross |  |  |  |  |  |  |
| F1  Generation  Cross |  |  |  |  |  |  |

**IV. Analysis & Conclusions**

**1. Describe the phenotypes and genotypes of the parents that you chose on the Punnett**

**squares screen.**

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**2. Describe the offspring phenotype and genotype ratios that resulted from crossing the**

**parents that you chose on the Punnett squares screen. Using these ratios, what**

**percentage of offspring is white-eyed? What percentage of offspring is red-eyed?**

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**3. Did you mate *Drosophila* in the laboratory or did you perform genetic crosses using**

**Punnett squares first? Why? Compare and contrast the data you collected from the**

**Punnett squares to the data you collected from the Drosophila mating.**

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**4. In a mating between a red-eyed male fruit fly and a red-eyed heterozygous female, what**

**percentage of the female offspring is expected to be carriers? How did you determine**

**the percentage?**

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**5. In a mating between a red-eyed male fruit fly and a white-eyed female fruit fly, what**

**percentage of the male offspring will have white eyes? Describe how you determined the**

**percentage.**

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**6. Hemophilia, a blood disorder in humans, results from a sex-linked recessive allele.**

**Suppose that a daughter of a mother without the allele and a father with the allele**

**marries a man with hemophilia. What is the probability that the daughter's children**

**will develop the disease? Describe how you determined the probability.**

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**7. Colorblindness results from a sex-linked recessive allele. Determine the genotypes of the**

**offspring that result from a cross between a color-blind male and a homozygous female**

**who has normal vision. Describe how you determined the genotypes of the offspring.**

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**8. Explain why sex-linked traits appear more often in males than in females.**

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