Drosophila Genetics Lab

Version 6.10

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Teacher Resource
and
Example Experiments

A Product of

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Experiments for both Standard and Special Editions

Introduction to Drosophila Genetics Lab

"Drosophila Genetics Lab" is a breeding simulation program, designed for use with students 16-19+ years old. The program and the Teacher Resource enable teachers of genetics to conduct realistic breeding experiments, in the classroom, over a few minutes rather than several months. The program is easily followed by both teachers and students, while the data obtained represents realistic experimental results.

The basic philosophy behind Drosophila Genetics, is the provision of a **high quality, low cost teaching resource**, which provides the student with experience in many laws of genetics, as well as in gathering and analysing data from realistic genetic experiments. In addition, the package is versatile enough to enable its use in a large variety of teaching strategies ranging from one computer - teacher directed breeding demonstrations to individual student - oriented data collection and analysis exercises. Selected experiments are ideally suited to use in assessment strategies.

Drosophila Genetics Lab does not normally provide the student with numbers, unless the teacher options have been set to allow auto-counting. However, by showing the student life like diagrams of random flies in each generation of offspring, the program **stimulates and develops skills of observation, categorisation and analysis**. By counting the individual flies the student gains a grassroots understanding of first-hand data. See the Teacher Options section for more details on auto-counting.

The example experiments provide students with basic questions on five types of crosses. These questions are by no means exhaustive and the teacher should add additional problems or questions, in the space provided at the end of each experiment. It is not recommended that all students do experiments 1-15, but rather the teacher should select one or two from each category. **To reduce the cost** of using Drosophila Genetics Lab in a teaching situation, Newbyte Educational Software ALLOWS THE DUPLICATION OF THE MANUAL, IN PART ONLY, FOR USE WITHIN THE SCHOOL OR INSTITUTION WHICH IS THE REGISTERED OWNER OF THE PACKAGE.

The **Site Licensed** version of this software provides the registered owner with the ability to install the software on as many computers. With a site license your school, college or institution can run this software on all networks within the one campus. This licence does not include student home use or access either via the school intranet or on their computers.

Laptop schools or those wishing to allow students secure access to the software via the school intranet will require a additional **Student Home Licence.**

Some possible uses include:
A teacher demonstration
Quickly demonstrate aspects of genetics, such as sex-linked and linked gene behaviour, to your class to emphasise classroom discussion.

Student experiments
Detailed experiments included in this manual enable your students to investigate five types of genetic inheritance and even calculate linkage distances for the standard edition. For the Special Edition only, Experiments 14 and above provide much more variety and opportunity for student discovery learning, projects and testing.

Student experimental design
By combining the use of the **Fly Construction Kit** and the breeding module your students can investigate many more examples of gene inheritance. Let them design experiments with Lobe eye which is a dominant trait. What happens when the mutation is lethal?

Student practical tests
Use the **integrated Construction Kit** in teacher mode to produce a fly which is heterozygous for some characteristics and homozygous for others, lock the fly's genotype and save it. Later allow your students to load the fly and conduct their own experiments to discover its genotype.

Student projects
Use the **Construction Kit** in teacher mode as above, lock the fly's genotype with **never show** and save it. Later allow your students to load the fly from the school network and conduct their own experiments to discover its genotype.

Limitations and Assumptions
For easy data collection and student understanding several aspects of this simulation have been simplified including:
1)   Crossing-over occurs uniformly along all the chromosomes.
2)   Crossing does not occur within 10 units of a previous crossing-over.
3)   It is possible to get many gene combinations which mask each other. For example eye colour or wing shape. A warning note is posted if such an individual is examined, however, it only states that there may be more than one gene active, it does not indicate particular genes. Its best to avoid more than one mutation in any one characteristic.

System requirements and installation

This is a Windows™ program. It will run in Windows XP, 2000, 98 etc. or Mac OS X for Macintosh.

SYSTEM REQUIREMENTS

Drosophila Genetics Lab requires these system components:
1. Pentium II 1.2 GHz or faster.
2. Windows XP etc operating system. (Mac OS X for Macintosh)
3. Approx. 20Mb free Hard Disk space.
4. Screen resolution of at least 1024 x 768 with Thousands of colours.

INSTALLATION
To setup Drosophila Genetics on your **Windows computer:**
   1. Place the Drosophila Genetics CD in your appropriate drive (e.g. D:).
   2. **Open the SETUP directory.**
   3. **Double-click on SETUP.msi file.**
   4. Follow the installation prompts.
   5. At the end of the installation the program will launch. You will then have to complete the installation process by entering your details. Use your full school name - initials may not be accepted.
   6. Your **Key Code** for the software is inside the DVD case.
   7. When the installation is complete you will be able to find a short-cut to the program at:
      Start > All Programs > Newbyte > Drosophila Genetics Lab.

To setup Drosophila Genetics on your **Macintosh OSX system:**
   1. Place the Drosophila Genetics CD in your appropriate drive.
   2. **Open the Macintosh directory.**
   3. Drag the Drosophila Genetics Lab folder to you hard disk.
   4. **Double click on the .hqx file to install the program.**
   5. Your **Key Code** for the software is inside the DVD case.

To Uninstall in Windows

1. Start the Windows operating system.
2. Run the installer again and it will give you the option to remove the program.

Teacher Options

One of the most versatile aspects of Drosophila Genetics Lab is its ability to respond to teacher options. It is important that you as the teacher decide, before your students start their breeding simulations, which genotype format is most appropriate for your aims and whether auto-counting will be required.

For example, if your students are simply doing the recommended experiments, the default is fine, however, if they are doing practical tests or projects then removing some of the options may help your objectives.

To confirm your changes you will need to enter the **Teacher ID Code**. In some teaching situations it may be ideal to get your students to change the code for you. For this reason the code changes every day. You can tell your students the code one day and it will be different the next. I'd only tell them once, after that, most would figure it out.

Teacher ID Code = 6dgp**X**tc   (**X** = Day + month)
e.g. if the date is 6 July then X= 6 + 7 = 13 the code would be 6dgp**13**tc
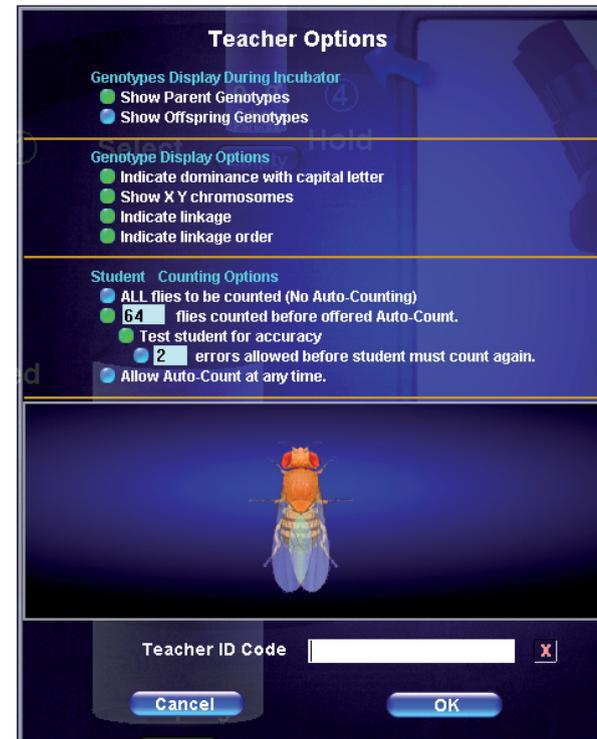
Important Notes:
● **Most experiments** I'd leave the setting as they are.
● **Problem solving work** try removing the XY and indication of dominance.
● **Advanced studies** the first 6 options may be turned off.
● **Check the options before your class.** Someone may have changed them for their own use.
● **Student Counting Options**
  ●**All flies to be counted:** for most experiments this is fine and gives the students a good feel for the data.
  ●**Flies counted before offered auto-count:** offers the best of both worlds this option also provides testing of student accuracy.
  ●**Auto-Count:** Good for very experienced students who don't need the practice with observation, categorisation and recording.

Fly Construction Kit - Teacher version

To enter **Teacher mode** select the **Teacher Construction Kit** menu item from the **OPTIONS** menu and enter the **teacher ID Code** shown on page 7 of this manual.

Teachers control the maternal and paternal genes.

Select Sex of fly being constructed.

Magnified View of body bristles.

Wing Veins - Mouse over the wings to see the wing veins clearly.

Genotype of fly being constructed.

Use the Fly as a Parent now or **Save** it for later.

Genotype Options control if the genotype is visible in the incubator.

Characteristic & the group to which it belongs.

Important Notes:

- **Teacher Mode:** The console has two lights/buttons per characteristic. This enables teachers to choose homozygous or heterozygous for any characteristic. You can choose up to 2 characteristics per character group if you wish heterozygous flies. However, its best to choose only one characteristic from each group to avoid over complicating the observation process.

- The maternal gene is on the left and the paternal on the right. This becomes obvious when you switch between male and female.

- **Be careful about letting students use this mode!**

- **Student Mode:** Only one light/button appears next to each characteristic. If selected the genotype of the individual will be set to homozygous, except in the case of lethal characteristics.

Drosophila Chromosome map

These are the current mutant genes which can be found in this program. Other genes will be added in the future and your program can be updated to the latest sub-version (i.e. version 6.0 to version 6.1) FREE from our web site. Check our web site for free upgrades before you start the genetics unit every year.

Also keep and eye on our web site for new stock flies which cannot be made in the Construction Kit.

1 (X)

0.0	yellow body
1.5	white eyes
13.7	crossveinless wing veins
21.0	singed bristles
33.0	vermilion eyes
51.5	scolloped wings
56.7	forked bristles
57.0	Bar eyes

2

6.1	Curly wings
13.0	dumpy wings
48.5	black body
54.5	purple eyes
55.2	apterous wings
67.0	vestigial wings
72.0	Lobe eyes
104.5	Plum eyes

3

26.0	sepia eyes
40.7	Dichaete wings
47.0	Incomplete wing veins
50.0	curled wings
58.2	Stubble bristles
58.5	aristapedia antennae & spineless bristles
70.7	ebony body

4

2.0	eyeless
3.0	shaven bristles

Drosophila Genetics Lab - Incubator

<table>
<tr><td>Buttons - Load and Save flies or pairs of flies.</td><td>Hold Jar Temporarily holds flies which will be the next parents.</td><td>Total Number of flies counted in this generation.</td></tr>
</table>

Magnify Bristles by moving the mouse over this icon.

View Wing Veins by moving the mouse over the wings.

Genotype of fly being studied, if available under teacher options.

<table>
<tr><td>Parents
Click or drag each fly over to examine it.</td><td>Offspring
Click or drag each fly over to examine it.</td><td>Automatically drops current fly into morgue and displays next fly.</td><td>Morgue
Drop a fly in here if you no longer require it.</td></tr>
</table>

Important Notes:
- **When starting the program** the first experiment has already been set up and the first 100 offspring breed. To observe the first offspring click on the arrow button near 3. The first parents are a Vestigial Winged female and a normal male.
- **Loading and Saving:** users are able to load and save pairs or individual flies.
- **Teachers:** take the time to read about **teacher options** on the previous page. These options can greatly enhance your use of this program in the widest variety of teaching strategies.
- **Small flies** can be moved about the screen by clicking on them and while holding down the left mouse button, dragging them to different areas on the screen. Be careful, a carelessly placed fly may wonder off and be lost.
- **Use the Holding Jars** to temporarily hold flies before using them as new parents in the next generation.

Using the Incubator

A simplified version of these instructions is in the procedure section of each experiment in the manual.

The incubator is easy to use while retaining excellent functionality.

To load a pair of flies for your next experiment, click on the **Select button** and choose to select **Saved Parents**. From the Open menu choose the experiment parents you wish and press OK. In some cases there are two versions Exp01_f.mfp and Exp01_m.mfp, the 'f' and 'm' indicate which fly is mutant.

It is also possible to **select pairs of flies** saved earlier and **even single flies** generated from the Construction Kit or saved in the Incubator.

To examine a fly simply click on or drag it to the microscope area.

To automate this process an Observe button has been placed beside the offspring. This button removes the fly currently being examined and moves another into place. When observing parents, click on the other parent to swap them when one is being observed.

Once an offspring has been moved from its area it can not be replaced. This prevents flies being counted twice.

A feature of this program is the **unlimited offspring** which can be bred (100 at a time) and the **unlimited number of generations** available.

To breed offspring press the Breed button. Observe and record these flies then press the breed button again to produce another 100 offspring.

To breed the next generation you will need to place a male and female fly in the **hold jar** then **empty the Parent jar.** This enables you to place the new parents into the parent area. The new parents may be 2 offspring, 1 parent & 1 offspring or even include a new fly created in the Construction Kit.

Parents are not parents until they have been bred. Under default conditions their genotype will not be visible until after they have been bred.

The morgue can not be opened.

Menus used in Drosophila Genetics Lab

File

> **Load**- load an existing experiment pairs of flies or individual flies.
> **Save** - save the present experiment pair of flies or a single fly.
> **Print** - print the screen or the current fly being observed.
> **Exit** - exit the program and return to Windows.

Options

> **Change Group Name** - name printed in reports.
>
> **View Fly Information** - displays the current fly's name and info.
> **Print Fly Information** - prints fly's data.
>
> **Change Construction Kit** - (Construction Kit only) allows you to swap between Teacher and Student Construction Kits.
>
> **Teacher Options** - teacher control of genotype displays.
> **Genotype Display Options**
> - Select the type of genotype required:
>
> | | | |
> |---|---|---|
> | Vg | vg | (most informative) |
> | V | v | (single letter) |
> | vg+ | vg | (recommended) |
> | + | vg | (wild gene +) |
> | + | v | (wild gene +, single) |
>
> **Auto-Count** - (Incubator only) - this option becomes active under different conditions, depending on the Teacher Option Settings. When active, this option allows you to automatically count up to 100,000 flies.

Reset

> In **Incubator** - All flies are removed ready for a new experiment.
> In **Construction Kit** - all mutations are set to normal and a female fly is selected.

Help

> **Points to Remember** - Helpful hints or both the Incubator and the Construction Kit.
> **About Drosophila Genetics Lab**
> Information on program developer and version.

Fly Construction Kit - Student

To enter the Student Construction Kit click the Construction Kit button at the top left of the screen.

Select the Mutations control the maternal and paternal genes.

Select Sex of fly being constructed.

Magnified View of body bristles.

Wing Veins - Mouse over the wings to see the wing veins clearly.

Genotype of fly being constructed.

Use the Fly as a Parent now or **Save** it for later.

Genotype Options control if the genotype is visible in the incubator.

Characteristic & the group to which it belongs.

You can construct your own mutant fly. Selecting a characteristic will make your fly **homozygous** for that mutant characteristic.

There are 9 characteristic groups on the console and you can select one characteristic from each. In most cases, however, **you should try to have as few mutations as possible**.

After you have constructed your mutant fly, select when you wish its genotype displayed in the breeding program.

- **Always** lets the genotype be visible to all.
- **Lock Code** lets you hide it until someone enters your code word.
- **Never** is a very long time - make sure you printout or record the flies information before you save it.

Click on Save to name and save your own fly or use it as a parent now.

Drosophila melanogaster Phenotypes

Wild Female
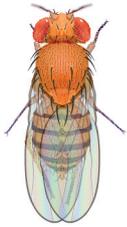
Wild Male
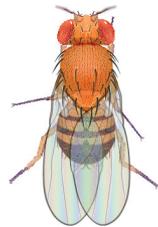
Eye Colour

| Wild | Plum | Purple | Sepia | Vermilion | White |

Eye Shape

| Wild | Bar | Wide-Bar | Eyeless | Lobe |

Body Colour
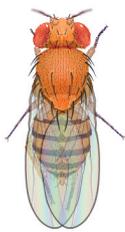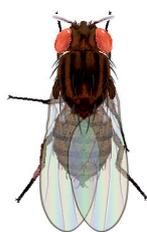
| Wild | Black | Ebony | Yellow |
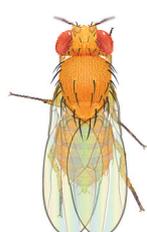
Body Bristles

| Wild | Forked | Shaven | Spineless | Stubble | Singed |

Wing Size
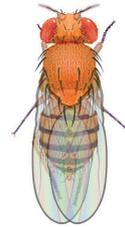
| Wild | Apterous | Vestigial |
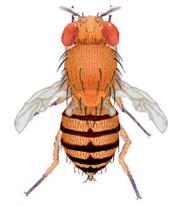
Wing Shape
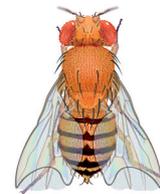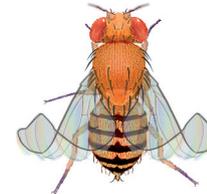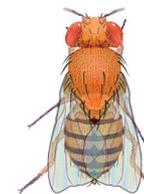
| Curled | Curly | Dumpy | Scolloped |
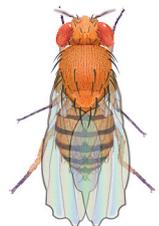
Wing Veins
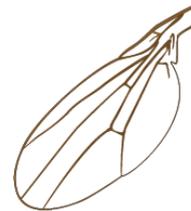
| Wild | Crossveinless | Incomplete | Crossveinless Incomplete |

Wing Shape
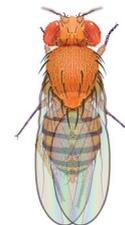
| Wild | Dichaete |
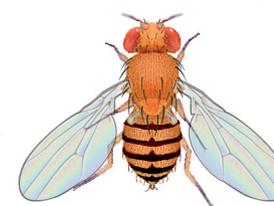
Antennae

| Wild | Aristapedia |

Exp 1   Single Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of a single gene which governs wing shape in Drosophila melanogaster fruit flies. The gene is found on the second chromosome of our flies and normally results in the fly having a wild flat wing shape. However, a mutant allele has been found which causes the wing to become twisted and useless. This wing shape is called vestigial and the allele causing the change in shape is called the vestigial wing allele.

A heterozygous fly possesses an allele for the wild wing shape and an allele for vestigial wing. As wild wing shape is dominant to vestigial, the fly will possess a wild wing phenotype. The symbol used for the wild allele is Vg and the mutant vg.

Wild Female	Vestigial Wing Female	Wild Male	Vestigial Wing Male

Aim
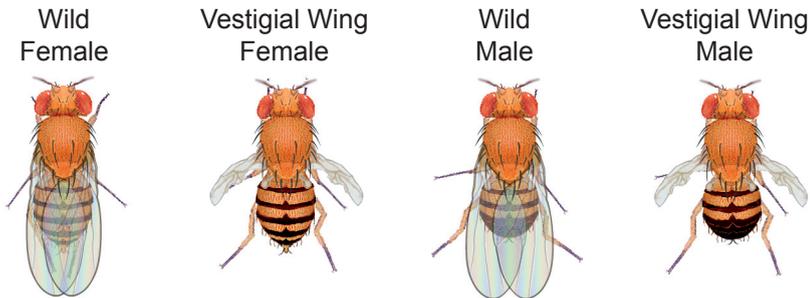
To examine the inheritance of the single mutant allele for vestigial wing, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp01_f.mfp** or **Exp01_m.mfp.** (f & m are the mutant's sex)
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent jar and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 200 offspring, then answer the questions.

Results   Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Wing flies		Vestigial Wing flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total Vestigial flies =	

Fly ratio Wild : Vestigial _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Wing flies	Vestigial Wing flies
Total Wild flies =	Total Vestigial flies =

Fly ratio Wild : Vestigial _____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous vestigial** winged individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female
phenotype:_____
genotype :_____

Male
phenotype:
_____   _____
_____   _____
genotype:
_____   _____

GAMETE genotypes   _____   _____   _____   _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to vestigial flies to be?

_____ : _____

4) How well does the ratio of **wild : vestigial winged** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Why are there usually differences between the number of males and the number of females observed in a random sample of flies?

_____

6) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

7) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female
phenotype:_____
genotype :_____

Male
phenotype:
_____   _____
_____   _____
genotype:
_____   _____

GAMETE genotypes   _____   _____   _____   _____

From the Punnett Square above, what is the expected ratio of NORMAL flies to vestigial winged flies?

_____ : _____

What are the expected ratios of genotypes?
(VgVg : Vgvg : vgvg) _____ : _____ : _____

8) How well does the ratio of **wild : vestigial** winged flies observed in the experiment compare to the ratio predicted by the Punnett Square?

_____

9) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

_____

_____

Additional Questions

Exp 2   Single Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of a single gene which governs wing shape in Drosophila melanogaster fruit flies. The gene is found on the third chromosome of our flies and normally results in the fly having a wild flat wing shape. However, a mutant allele has been found which causes the wing curl. This wing shape is called curled and the allele causing the change in shape is called the curled wing allele.

A heterozygous fly possesses an allele for the wild wing shape and an allele for curled wing shape. As wild wing shape is dominant to curled, the fly will possess a wild wing phenotype. The symbol used for the wild allele is Cu and the mutant cu.

Wild Female	Curled Wing Female	Wild Male	Curled Wing Male

Aim

To examine the inheritance of the single mutant gene for curled wing, in three generations of *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents..
2.   Select **Exp02_f.mfp** or **Exp02_m.mfp.** (f & m are the mutant's sex)
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4.   Click the Breed button and record each offspring's phenotype.
5.   During recording, drag a male and female offspring into the Hold Jar.
6.   Empty the Parent/Offspring area after counting 50 - 100 offspring.
7.   Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8.   Record the phenotypes of 200 offspring, then answer the questions.

Results   Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild Wing flies		Curled Wing flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total Curled flies =	

Fly ratio Wild : Curled _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild Wing flies	Curled Wing flies
Total Wild flies =	Total Curled flies =

Fly ratio Wild : Curled _____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous curled** winged individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

Male

GAMETE genotypes _____ _____ _____ _____

phenotype:

_____ _____

_____ _____

genotype:

_____ _____

_____ _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to curled flies to be?

_____ : _____

4) How well does the ratio of **wild : curled winged** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Why are there usually differences between the number of males and the number of females observed in a random sample of flies?

_____

6) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

7) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

Male

GAMETE genotypes _____ _____ _____ _____

phenotype:

_____ _____

_____ _____

genotype:

_____ _____

_____ _____

From the Punnett Square above, what is the expected ratio of NORMAL flies to curled winged flies?

_____ : _____

What are the expected ratios of genotypes?

(CuCu : Cucu : cucu) _____ : _____ : _____

8) How well does the ratio of **wild : curled** winged flies observed in the experiment compare to the ratio predicted by the Punnett Square?

_____

9) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

_____

_____

Additional Questions
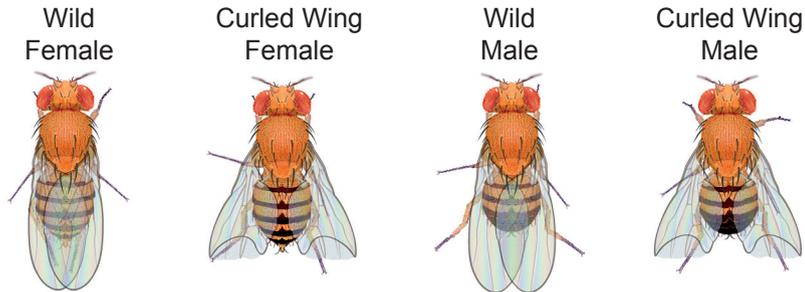
Exp 3   Single Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of a single gene which governs body colour in Drosophila melanogaster fruit flies. The gene is found on the third chromosome of our flies and normally results in the fly having an orange body. However, a mutant allele has been found which causes the body to darken. This colour is called ebony and the allele causing the change is called the ebony body allele.

As wild body colour is dominant to ebony, a heterozygous fly will possess a wild body phenotype. The symbol used for the wild allele is Eb and the mutant eb.

Wild Female	Ebony Body Female	Wild Male	Ebony Body Male

Aim
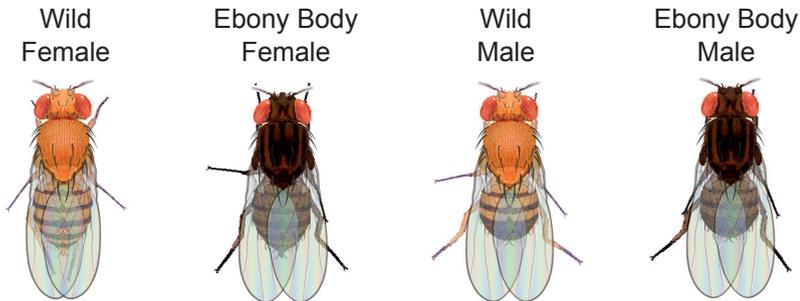
To examine the inheritance of the single mutant gene for ebony body colour, in three generations of *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp03_f.mfp** or **Exp03_m.mfp.** (f & m are the mutant's sex)
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4.   Click the Breed button and record each offspring's phenotype.
5.   During recording, drag a male and female offspring into the Hold Jar.
6.   Empty the Parent/Offspring area after counting 50 - 100 offspring.
7.   Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8.   Record the phenotypes of 200 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description			
Female Phenotype -		Genotype -	
Male " -		" -	
Wild Bodied flies		Ebony Bodied flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total Ebony flies =	

Fly ratio Wild : Ebony _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description	
Female Phenotype -	Genotype -
Male " -	" -
Wild Bodied flies	Ebony Bodied flies
Total Wild flies =	Total Ebony flies =

Fly ratio Wild : Ebony _____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous ebony** winged individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

Male

GAMETE genotypes _____ _____ _____ _____

phenotype:

_____ _____

_____ _____

genotype: _____

_____ _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to ebony flies to be?

_____ : _____

4) How well does the ratio of **wild : ebony bodied** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Why are there usually differences between the number of males and the number of females observed in a random sample of flies?

_____

6) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

7) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

Male

GAMETE genotypes _____ _____ _____ _____

phenotype:

_____ _____

_____ _____

genotype: _____

_____ _____

From the Punnett Square above, what is the expected ratio of NORMAL flies to ebony bodied flies?

_____ : _____

What are the expected ratios of genotypes?
(EbEb : Ebeb : ebeb) _____ : _____ : _____

8) How well does the ratio of **wild : ebony** winged flies observed in the experiment compare to the ratio predicted by the Punnett Square?

_____

9) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

_____

_____

Additional Questions

Exp 4   Double Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of two genes found on different chromosomes, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **vestigial wing** (2) and **ebony body** (3) genes. Both wild genes are **dominant** over the **mutant** genes.

Wild Female	Vestigial Wing Female	Wild Male	Vestigial Wing Male

Ebony Body Female	Vestigial & Ebony Female	Ebony Body Male	Vestigial & Ebony Male

Aim

To examine the inheritance of two mutant genes, occurring on separate chromosomes, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp04_f.mfp** or **Exp04_m.mfp.** (f & m are the mutant's sex)
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 300 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild flies	Vestigial Wing flies	Ebony Bodied flies	Vestigial Wing & Ebony Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Mutant _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild flies	Vestigial Wing flies	Ebony Bodied flies	Vestigial Wing & Ebony Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Vestigial : Ebony : Vestigial & Ebony

_____:_____:_____:_____

Discussion Questions

1)   Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female
phenotype:_____

genotype :_____

Male
phenotype:
_____

_____

genotype:
_____

GAMETE genotypes   _____ _____ _____ _____

_____

_____

_____

_____

3)   By referring to the Punnett Square above, what would you expect the ratio of wild flies to mutant flies to be?

_____ : _____

4) How well does the ratio of **wild : mutant** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5)   Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6)   Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female
phenotype:_____

genotype :_____

Male
phenotype:
_____

_____

genotype:
_____

GAMETE genotypes   _____ _____ _____ _____

_____

_____

_____

_____

From the Punnett Square above, what is the expected ratio of
   Wild : Vestigial : Ebony : Vestigial & Ebony flies

_____:_____ : _____ : _____

7)   How well does the ratio of Wild : Vestigial : Ebony : Vestigial & Ebony flies observed in the experiment compare to the predicted ratio?

_____

8) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?
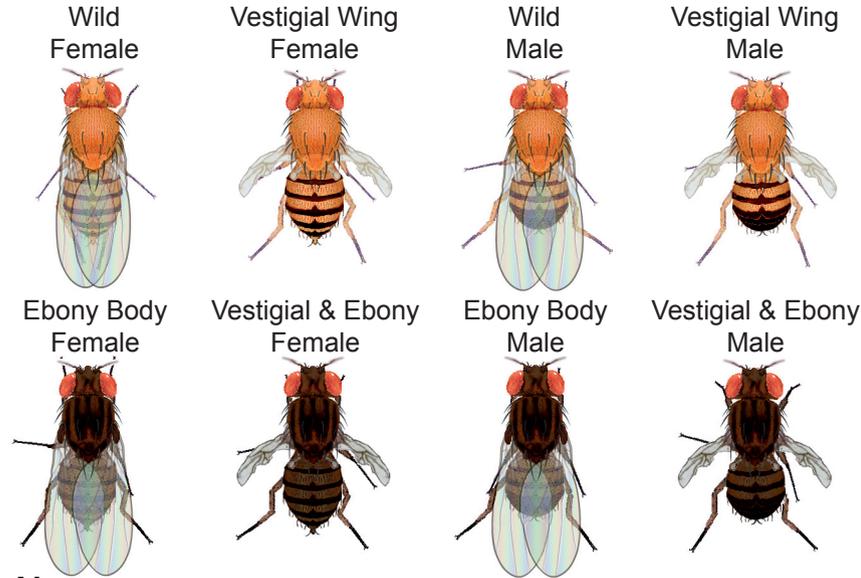
_____

_____

Additional Questions

Exp 5   Double Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of two genes found on different chromosomes, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **black body** (2) and **curled wing** (3) genes. Both wild genes are **dominant** over the **mutant** genes.

Wild Female	Black Body Female	Wild Male	Black Body Male

Curled Wing Female	Black & Curled Female	Curled Wing Male	Black & Curled Male

Aim

To examine the inheritance of two mutant genes, occurring on separate chromosomes, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp05_f.mfp** or **Exp05_m.mfp.** (f & m are the mutant's sex)
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 300 offspring, then answer the questions.

Results   Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild flies	Curled Wing flies	Black Bodied flies	Curled Wing & Black Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Mutant _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild flies	Curled Wing flies	Black Bodied flies	Curled Wing & Black Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Curled : Black : Curled & Black

_____:_____:_____:_____

Discussion Questions

1)   Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____   _____

_____   _____

genotype:

_____

_____   _____

GAMETE genotypes   _____ _____ _____ _____

3)   By referring to the Punnett Square above, what would you expect the ratio of wild flies to mutant flies to be?

_____ : _____

4)   How well does the ratio of **wild : mutant** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5)   Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____   _____

_____   _____

genotype:

_____

_____   _____

GAMETE genotypes   _____ _____ _____ _____

From the Punnett Square above, what is the expected ratio of
Wild : Curled : Black : Curled & Black flies

_____:_____ : _____ : _____

7)   How well does the ratio of Wild : Curled : Black : Curled & Black flies observed in the experiment compare to the predicted ratio?

_____

8)   Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

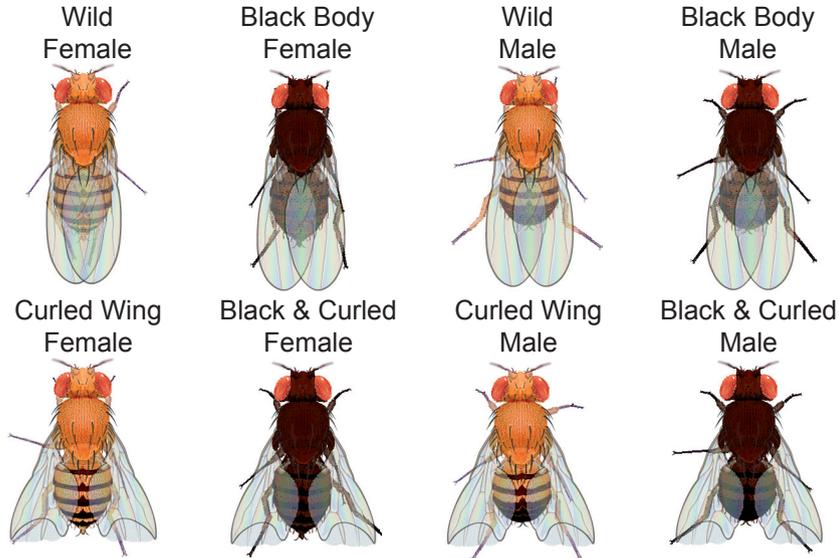_____

_____

Additional Questions

Exp 6   Sex-Linked Inheritance

Name : _____   Date:_____

Introduction

In *Drosophila melanogaster*, as in humans, sex is determined by the **sex chromosomes** X and Y. An XX individual is female while an XY is male. A gene found on the X chromosome which has no corresponding gene on the Y is said to be **sex-linked**. White eyes in Drosophila is sex-linked, as is red-green colour blindness in humans.

The wild gene for red eye colour is **dominant** over the **mutant** gene. The symbol used for the wild gene is **W** and the mutant **w**. A **hybrid female X^{W}X^w**, would have the wild eye colour. A male has only one chromosome containing the gene and so will either be **X^{W}Y$^-$** or **X^{w}Y$^-$**.

Wild Female	White Eyed Female	Wild Male	White Eyed Male

Aim

To examine the inheritance of the sex linked gene for white eyes, from a **white eyed male**, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp06.mfp**.
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 200 offspring, then answer the questions.

Results   Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild Eyed flies		White Eyed flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total White flies =	

Fly ratio Wild : White Eyed Flies _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -   Genotype -
Male   "   -   "   -

Wild Eyed flies		White Eyed flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total White flies =	

Fly ratio Wild female : Wild male : White Eyed female : White Eyed male

_____:_____:_____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** female and a **homozygous white eyed** male individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female
phenotype:_____

genotype :_____

Male
phenotype:

_____ _____

_____ _____
genotype:

_____ _____

GAMETE genotypes _____ _____ _____ _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to white eyed flies to be?

_____ : _____

4) How well does the ratio of **wild : white eyed** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female
phenotype:_____

genotype :_____

Male
phenotype:

_____ _____

_____ _____
genotype:

_____ _____

GAMETE genotypes _____ _____ _____ _____

From the Punnett Square above, what is the expected ratio of Wild female : Wild male : White Eyed female : White Eyed male

_____:_____:_____:_____

What are the expected ratios of genotypes?
(X^wX^w : X^wY^- : X^wX^w : X^wY^-)_____:_____:_____:_____

7) How well does the ratio of Wild female : Wild male : White Eyed female : White Eyed male flies observed, compare to the ratio predicted?

_____

8) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

_____

_____

Additional Questions

Do experiment 7 and compare its results to these.
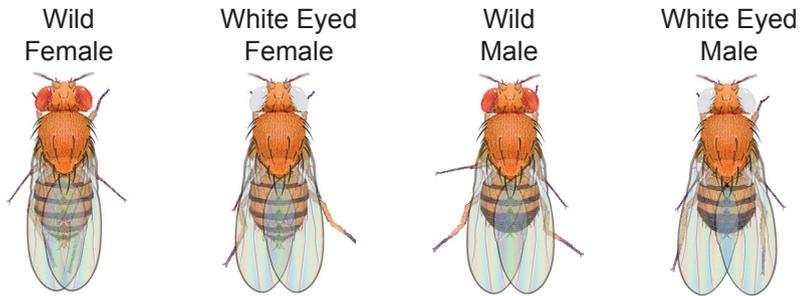
Exp 7   Sex-Linked Inheritance

Name : _____   Date:_____

Introduction

In *Drosophila melanogaster*, as in humans, sex is determined by the **sex chromosomes** X and Y. An XX individual is female while an XY is male. A gene found on the X chromosome which has no corresponding gene on the Y is said to be **sex-linked**. White eyes in Drosophila is sex-linked, as is red-green colour blindness in humans.

The wild gene for red eye colour is **dominant** over the **mutant** gene. The symbol used for the wild gene is **W** and the mutant **w**. A **hybrid female** $X^W X^w$, would have the wild eye colour. A male has only one chromosome containing the gene and so will either be $X^W Y^-$ or $X^w Y^-$.

Wild Female	White Eyed Female	Wild Male	White Eyed Male

Aim

To examine the inheritance of the sex linked gene for white eyes, from a **white eyed female**, in three generations of *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp07.mfp**.
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4.   Click the Breed button and record each offspring's phenotype.
5.   During recording, drag a male and female offspring into the Hold Jar.
6.   Empty the Parent/Offspring area after counting 50 - 100 offspring.
7.   Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8.   Record the phenotypes of 200 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Eyed flies		White Eyed flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total White flies =	

Fly ratio Wild : White Eyed Flies _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Eyed flies		White Eyed flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total White flies =	

Fly ratio Wild female : Wild male : White Eyed female : White Eyed male

_____:_____:_____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** female and a **homozygous white eyed** male individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____   _____

_____   _____

genotype:

_____   _____

_____   _____

GAMETE genotypes   _____ _____ _____ _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to white eyed flies to be?

_____ : _____

4) How well does the ratio of **wild : white eyed** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____   _____

_____   _____

genotype:

_____   _____

_____   _____

GAMETE genotypes   _____ _____ _____ _____

From the Punnett Square above, what is the expected ratio of Wild female : Wild male : White Eyed female : White Eyed male

_____:_____:_____:_____

What are the expected ratios of genotypes?
($X^W X^w$: $X^W Y^-$: $X^w X^w$: $X^w Y^-$)_____:_____:_____:_____

7) How well does the ratio of Wild female : Wild male : White Eyed female : White Eyed male flies observed, compare to the ratio predicted?

_____

8) Why would you expect a difference, between the observed and predicted **phenotypic ratios**?

_____

_____

Additional Questions
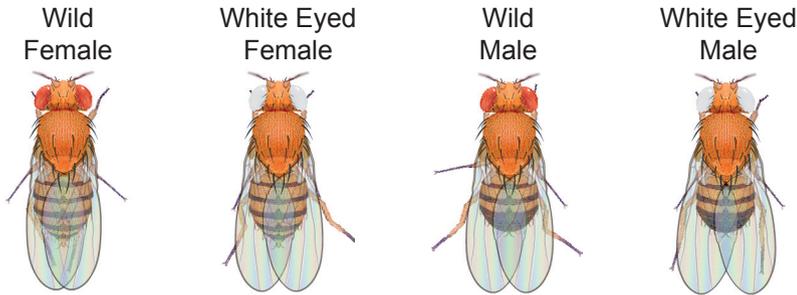
Do experiment 6 and compare its results to these.

Exp 8　Sex-Linked Incomplete Dominance

Name : _____　　Date:_____

Introduction

In *Drosophila melanogaster*, as in humans, sex is determined by the **sex chromosomes** X and Y.　An XX individual is female while an XY is male.

A gene found on the X chromosome which has no corresponding gene on the Y is said to be **sex-linked**.　An unusual sex-linked gene studied in Drosophila is the mutant gene for **Bar Eye**, which is given the symbol **B**. The mutant gene causes a marked reduction in the number of eye facets, resulting in small and narrow eye.

The **Bar Eye** gene **not recessive** to the wild gene for round eye shape, which is given the symbol B^+.　A female with $X^B X^B$ will have bar eyes while a female with $X^B X^{B+}$ will have an intermediate sized eye called **wide-bar**.　The bar eye gene expresses itself even when a wild gene is present. This is a case of **incomplete dominance**.

Since males have only one gene for this characteristic their genotype will be either $X^{B+}Y^-$ or $X^B Y^-$.

Wild Eye	Bar Eye	Wide-Bar Eye

Aim

To examine the inheritance of the sex linked gene for white eyes, from a **bar eyed male**, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp08.mfp**.
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 200 offspring, then answer the questions.

Results　　Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -　　　　　　　Genotype -
Male　　　　"　-　　　　　　　　"　-

	Female			Male	
Wild	Bar	Wide-Bar	Wild	Bar	Wide-Bar
total =	=	=	=	=	=

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -　　　　　　　Genotype -
Male　　　　"　-　　　　　　　　"　-

	Female			Male	
Wild	Bar	Wide-Bar	Wild	Bar	Wide-Bar
total =	=	=	=	=	=

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** female and a **homozygous bar eyed** male individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

GAMETE genotypes   _____   _____

Male

phenotype:

_____   _____

genotype:

_____   _____

3) By referring to the Punnett Square above, would you expect any wild eyed or bar eyed females to appear in the first generation? Why?

_____

_____

_____

4) Would you expect any wild male flies to appear in the first generation? Why?

_____

_____

_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

GAMETE genotypes   _____   _____

Male

phenotype:

_____   _____

genotype:

_____   _____

From the Punnett Square above, what is the expected ratio of
Wild female : Wild male : Bar female : Bar male : Wide-Bar female

_____:_____:_____:_____:_____

What are the expected ratios of genotypes?

$(X^{B+}X^{B+} : X^{B+}Y^- : X^BX^B : X^BY^- : X^{B+}X^B)$_____:_____:_____:_____:_____

7) How well does the ratio of Wild female : Wild male : Bar female : Bar male : Wide-Bar female flies observed, compare to the ratio predicted?

_____

8) Why would you expect no female flies with bar eyes to appear in the second generation of offspring?

_____

_____

Additional Questions
Do experiment 9 and compare the results with these.

Exp 9   Sex-Linked Incomplete Dominance

Name : _____   Date:_____

Introduction

In *Drosophila melanogaster*, as in humans, sex is determined by the **sex chromosomes** X and Y.   An XX individual is female while an XY is male.

A gene found on the X chromosome which has no corresponding gene on the Y is said to be **sex-linked**. An unusual sex-linked gene studied in Drosophila is the mutant gene for **Bar Eye**, which is given the symbol **B**. The mutant gene causes a marked reduction in the number of eye facets, resulting in small and narrow eye.

The **Bar Eye** gene **not recessive** to the wild gene for round eye shape, which is given the symbol **B⁺**. A female with $X^B X^B$ will have bar eyes while a female with $X^B X^{B+}$ will have an intermediate sized eye called **wide-bar**. The bar eye gene expresses itself even when a wild gene is present. This is a case of **incomplete dominance**.

Since males have only one gene for this characteristic their genotype will be either $X^{B+} Y^-$ or $X^B Y^-$.

Wild Eye	Bar Eye	Wide-Bar Eye

Aim

To examine the inheritance of the sex linked gene for white eyes, from a **bar eyed female**, in three generations of *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp09.mfp**.
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4.   Click the Breed button and record each offspring's phenotype.
5.   During recording, drag a male and female offspring into the Hold Jar.
6.   Empty the Parent/Offspring area after counting 50 - 100 offspring.
7.   Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8.   Record the phenotypes of 200 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description
Female Phenotype -   Genotype -

Male   "   -   "   -

Female			Male		
Wild	Bar	Wide-Bar	Wild	Bar	Wide-Bar
total =	=	=	=	=	=

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description
Female Phenotype -   Genotype -

Male   "   -   "   -

Female			Male		
Wild	Bar	Wide-Bar	Wild	Bar	Wide-Bar
total =	=	=	=	=	=

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** female and a **homozygous bar eyed** male individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female

phenotype:_____

genotype :_____

GAMETE genotypes _____   _____

Male

phenotype:

_____   _____

_____

genotype:

_____   _____

3) By referring to the Punnett Square above, would you expect any wild eyed or bar eyed females to appear in the first generation? Why?

_____
_____
_____

4) Would you expect any wild male flies to appear in the first generation? Why?

_____
_____
_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

GAMETE genotypes _____   _____

Male

phenotype:

_____   _____

_____

genotype:

_____   _____

From the Punnett Square above, what is the expected ratio of
Wild female : Wild male : Bar female : Bar male : Wide-Bar female

_____:_____:_____:_____:_____

What are the expected ratios of genotypes?

($X^{B+}X^{B+}$: $X^{B+}Y^-$: X^BX^B : X^BY^- : $X^{B+}X^B$)_____:_____:_____:_____:_____

7) How well does the ratio of Wild female : Wild male : Bar female : Bar male : Wide-Bar female flies observed, compare to the ratio predicted?

_____

8) Why would you expect no female flies with bar eyes to appear in the second generation of offspring?

_____
_____

Additional Questions
Do experiment 8 and compare the results with these.

Exp 10   Linked Inheritance

Name : _____   Date:_____

Introduction
In this experiment we will examine the inheritance of two genes found on the **same autosomal chromosome**, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **curled wing** and **ebony body** genes. Both wild genes are **dominant** over the **mutant** genes.

One way to show two genes are on the same chromosome is to draw a line under the genotypes, for example Cu Eb. Using this method an individual with one chromosome Cu Eb and the other cu eb can have its genotype written like this: Cu Eb
                                 cu eb

The inheritance of linked genes, from generation to generation, is very different to genes found on separate chromosomes. During this experiment we will discover some of those differences and the reasons they exist.

Wild Female	Curled Wing Female	Wild Male	Curled Wing Male
Ebony Body Female	Curled & Ebony Female	Ebony Body Male	Curled & Ebony Male

Aim
To examine the inheritance of two mutant genes, occurring on the **same autosomal chromosome**, in three generations of *Drosophila melanogaster* flies.

Procedure
1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp10.mfp**.
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 300 offspring, then answer the questions.

Results
Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description			
Female Phenotype -		Genotype -	
Male " -		" -	
Wild flies	**Curled Wing flies**	**Ebony Bodied flies**	**Curled Wing & Ebony Bodied**
Total =	Total =	Total =	Total =

Fly ratio Wild : Mutant _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild flies	Curled Wing flies	Ebony Bodied flies	Curled Wing & Ebony Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Curled : Ebony : Curled & Ebony

_____:_____:_____:_____

Discussion Questions

1)   Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female phenotype:_____

genotype :_____

GAMETE genotypes

Male

phenotype:

_____

_____ _____

genotype:

_____ _____

3)   By referring to the Punnett Square above, what would you expect the ratio of wild flies to mutant flies to be?

_____ : _____

4)   How well does the ratio of **wild : mutant** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female phenotype:_____

genotype :_____

Male

GAMETE genotypes _____   _____   _____   _____

phenotype:

————————— _____

_____ _____

genotype: _____

_____ _____

From the Punnett Square above, what is the expected ratio of
Wild : Curled : Ebony : Curled & Ebony flies?

_____:_____:_____:_____

7) How well does the ratio of Wild : Curled : Ebony : Curled & Ebony flies observed in the experiment compare to the predicted ratio above?

_____

8) If this was a normal **Mendelian Cross** with genes on different autosomal chromosomes, what would be the expected ratio of
Wild : Curled : Ebony : Curled & Ebony flies?

_____:_____:_____:_____

9) If the curled and ebony genes were permanently linked and could not separate under any conditions, what would be the expected ratio of
Wild : Curled : Ebony : Curled & Ebony flies?

_____:_____:_____:_____

10) What were your observed ratios of
Wild : Curled : Ebony : Curled & Ebony flies?

_____:_____:_____:_____

11) How could the flies showing only one mutation arise? (it may be necessary to alter your Punnett Square while answering this question)

_____
_____
_____
_____

12) If the two mutant genes were further apart on the third chromosome, predict the effect on the ratio of single mutant individuals to total flies in the F2 generation. Would the ratio increase or decrease? Why?

_____
_____
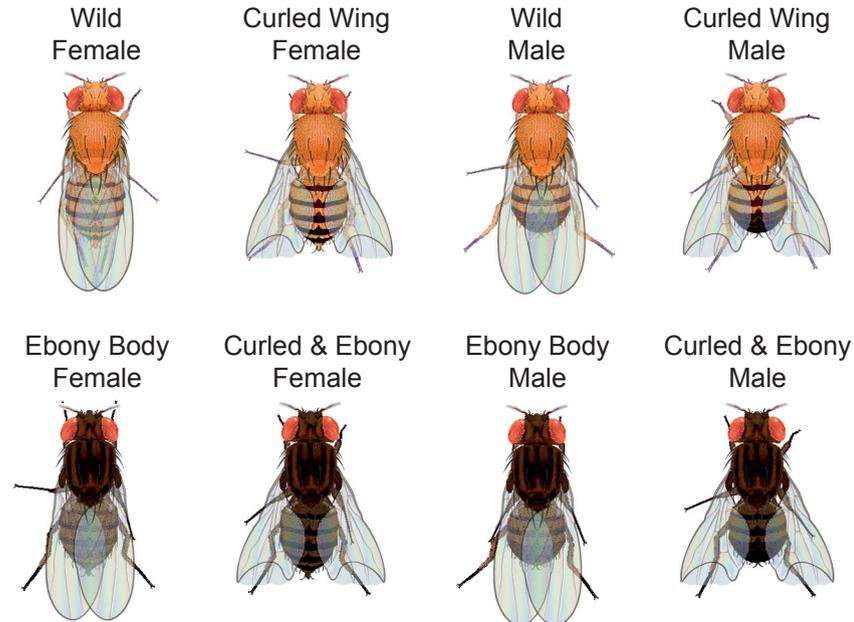_____

Additional Questions

Exp 11   Linked Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of two genes found on the **same autosomal chromosome**, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **vestigial wing** and **black body** genes. Both wild genes are **dominant** over the **mutant** genes.

One way to show two genes are on the same chromosome is to draw a line under the genotypes, for example Vg Bk. Using this method an individual with one chromosome Vg Bk and the other vg bk can have its genotype written like this: Vg Bk
$$\frac{Vg\ \ Bk}{vg\ \ \ bk}$$

The inheritance of linked genes, from generation to generation, is very different to genes found on separate chromosomes. During this experiment we will discover some of those differences and the reasons they exist.

Wild Female	Vestigial Wing Female	Wild Male	Vestigial Wing Male

Black Body Female	Vestigial & Black Female	Black Body Male	Vestigial & Black Male

Aim
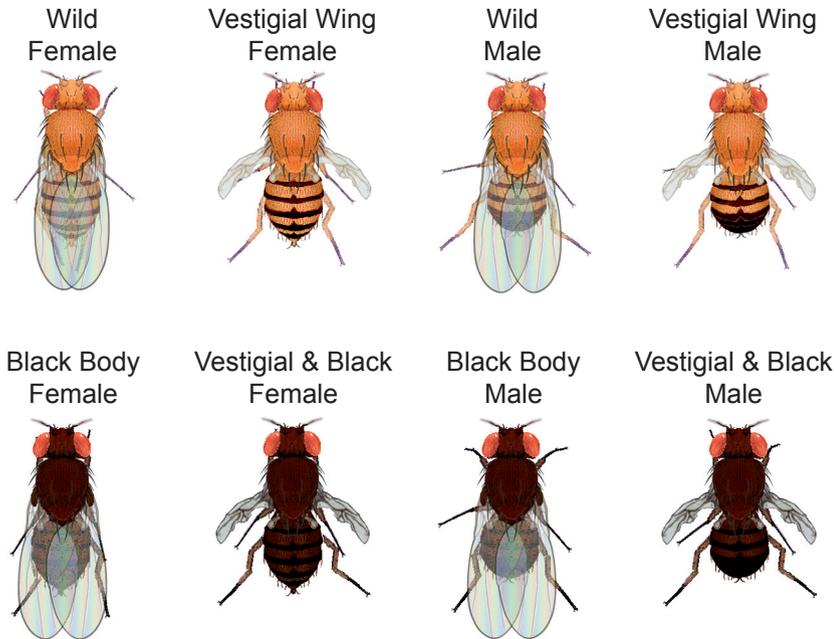
To examine the inheritance of two mutant genes, occurring on the **same autosomal chromosome**, in three generations of *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp11.mfp**.
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4.   Click the Breed button and record each offspring's phenotype.
5.   During recording, drag a male and female offspring into the Hold Jar.
6.   Empty the Parent/Offspring area after counting 50 - 100 offspring.
7.   Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8.   Record the phenotypes of 300 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description			
Female Phenotype -		Genotype -	
Male " -		" -	
Wild flies	Vestigial Wing flies	Black Bodied flies	Vestigial Wing & Black Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Mutant _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild flies	Vestigial Wing flies	Black Bodied flies	Vestigial Wing & Black Bodied
Total =	Total =	Total =	Total =

Fly ratio Wild : Vestigial : Black : Vestigial & Black

_____:_____:_____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female   phenotype:_____

genotype :_____

Male   GAMETE genotypes   _____   _____

phenotype:

_____   _____

genotype:

_____   _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to mutant flies to be?

_____ : _____

4) How well does the ratio of **wild : mutant** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____

_____

_____

5) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

6) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____

_____

genotype:

_____

GAMETE genotypes

_____ _____ _____ _____

_____

_____

_____

_____

From the Punnett Square above, what is the expected ratio of
Wild : Vestigial : Black : Vestigial & Black flies?

_____:_____:_____:_____

7) How well does the ratio of Wild : Vestigial : Black : Vestigial & Black flies observed in the experiment compare to the predicted ratio above?

_____

8) If this was a normal **Mendelian Cross** with genes on different autosomal chromosomes, what would be the expected ratio of
Wild : Vestigial : Black : Vestigial & Black flies?

_____:_____:_____:_____

9) If the vestigial and black genes were permanently linked and could not separate under any conditions, what would be the expected ratio of
Wild : Vestigial : Black : Vestigial & Black flies?

_____:_____:_____:_____

10) What were your observed ratios of
Wild : Vestigial : Black : Vestigial & Black flies?

_____:_____:_____:_____

11) How could the flies showing only one mutation arise? (it may be necessary to alter your Punnett Square while answering this question)

_____

_____

_____

_____

12) If the two mutant genes were further apart on the third chromosome, predict the effect on the ratio of single mutant individuals to total flies in the F2 generation. Would the ratio increase or decrease? Why?

_____

_____

_____

Additional Questions

Exp 12 Calculation of Linkage Distance

Name : _____   Date:_____

Introduction

In this experiment we will calculate the distance between two genes found on the **third autosomal chromosome**, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **curled wing** and **ebony body** genes. Both wild genes are **dominant** over the **mutant** genes.

One way to show two genes are on the same chromosome is to draw a line under the genotypes, for example Cu Eb. Using this method an individual with one chromosome Cu Eb and the other cu eb can have its genotype written like this: Cu Eb
                                     cu eb

T. H. Morgan, a geneticist who worked with Drosophila, proposed that linked genes are occasionally broken apart by some natural mechanism. This natural mechanism is called **crossing-over** and results in the formation of gametes which contain genes from both chromosomes. Using the example above, the individual fly would not only produce gametes of genotypes Cu Eb and cu eb, but also Cu eb and cu Eb. The percentage of these new genotypes depends on the distance between the genes on the chromosome.

Crossing-over can occur more than once on the same chromosome.

If we assume the chance of crossing-over is equal all along the chromosome, then the larger the distance between the two linked genes the greater the chance of getting these new combinations of genes. The percentage of crossing-over can therefore be used as a measure of the distance between the linked genes. **The unit used for measuring the distance between two linked genes is the distance within which crossing-over occurs one percent of the time.**

In this experiment the linkage distance between the linked genes will be determined by using a **testcross**. A testcross involves the breeding of a **heterozygous** individual with a **homozygous recessive** individual. In this way, the percentage of crossing-over in the heterozygote can be calculated by counting the number of offspring with only one of the characteristics. If no crossing-over occurs then all offspring will be either wild or show both mutations.

| Wild Female | Curled Wing Female | Wild Male | Curled Wing Male |
| Ebony Body Female | Curled & Ebony Female | Ebony Body Male | Curled & Ebony Male |

Aim

To calculate the **linkage distance** between two mutant genes on an **autosomal chromosome** of *Drosophila melanogaster*, using a **testcross**.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp12.mfp.**
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the table.
4.   Click the Breed button and record each offspring's phenotype.
5.   Record the phenotypes of 500 or more offspring, then answer the questions.

Table 1 Testcross Results

Parent Description			
Female Phenotype - Genotype -			
Male " - " -			
Wild flies	Curled Wing flies	Ebony Bodied flies	Curled Wing & Ebony Bodied
Total =	Total =	Total =	Total =

Discussion Questions

1) Complete the following table, which deals with the original **testcross**, between a **heterozygous** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **testcross**.

Female

phenotype:_____

genotype :_____

GAMETE genotypes   _____   _____   _____   _____

Male

phenotype:

_____   _____

_____   _____

genotype:

_____   _____

_____   _____

3) If the genes we are dealing with were permanently linked and could not separate under any conditions, what would be the expected ratio of Wild : Curled : Ebony : Curled & Ebony flies?

_____:_____:_____:_____

4) How could the flies showing only one mutation arise? (it may be necessary to alter your Punnett Square while answering this question)

_____

_____

_____

_____

5) Using the following equation, determine the linkage distance between the two genes investigated in this experiment.

Linkage Distance = $\dfrac{\underline{\textbf{Number of flies with only one mutation}}}{\textbf{Total number of flies counted}}$ **X** $\dfrac{\textbf{100}}{\textbf{1}}$

= _____ **X** $\dfrac{\textbf{100}}{\textbf{1}}$

= _____ **Units**

6) The actual distance between the curled and ebony genes is 20.7 units. How well did your result compare to the actual linkage distance and how may your results be improved?

_____

_____

_____

_____

7) The longer the distance between the linked genes, the greater the error. Even this distance is much longer than most would wish to measure accurately. Propose a way of more accurately measuring the distance between these two genes. (Hint: there are other genes)

_____

_____

_____

Additional Questions

Additional Questions Continued

Exp 13 Calculation of Linkage Distance

Name : _____   Date:_____

Introduction
In this experiment we will calculate the distance between two genes found on the **second autosomal chromosome**, in *Drosophila melanogaster* fruit flies. The genes used in this experiment are the **vestigial wing** and **black body** genes. Both wild genes are **dominant** over the **mutant** genes.
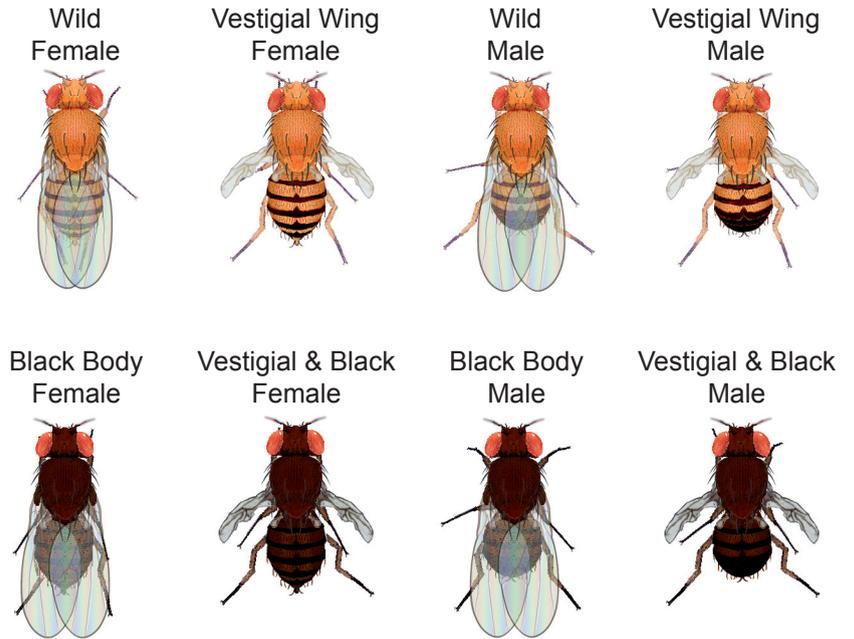
One way to show two genes are on the same chromosome is to draw a line under the genotypes, for example Vg Bk. Using this method an individual with one chromosome Vg Bk and the other vg bk can have its genotype written like this: Vg Bk
vg   bk

T. H. Morgan, a geneticist who worked with Drosophila, proposed that linked genes are occasionally broken apart by some natural mechanism. This natural mechanism is called **crossing-over** and results in the formation of gametes which contain genes from both chromosomes. Using the example above, the individual fly would not only produce gametes of genotypes Vg Bk and vg bk, but also Vg bk and vg Bk. The percentage of these new genotypes depends on the distance between the genes on the chromosome.

Crossing-over can occur more than once on the same chromosome.

If we assume the chance of crossing-over is equal all along the chromosome, then the larger the distance between the two linked genes the greater the chance of getting these new combinations of genes. The percentage of crossing-over can therefore be used as a measure of the distance between the linked genes. **The unit used for measuring the distance between two linked genes is the distance within which crossing-over occurs one percent of the time.**

In this experiment the linkage distance between the linked genes will be determined by using a **testcross**. A testcross involves the breeding of a **heterozygous** individual with a **homozygous recessive** individual. In this way, the percentage of crossing-over in the heterozygote can be calculated by counting the number of offspring with only one of the characteristics. If no crossing-over occurs then all offspring will be either wild or show both mutations.

Wild Female   Vestigial Wing Female   Wild Male   Vestigial Wing Male

Black Body Female   Vestigial & Black Female   Black Body Male   Vestigial & Black Male

Aim

To calculate the **linkage distance** between two mutant genes on an **autosomal chromosome** of *Drosophila melanogaster*, using a **testcross**.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp13.mfp**.
3.   Drag the each of the parents over to the Observation Platform and record their phenotype and genotype in the table.
4.   Click the Breed button and record each offspring's phenotype.
5.   Record the phenotypes of 500 or more offspring, then answer the questions.

Table 1 Testcross Results

Parent Description			
Female Phenotype - Genotype -			
Male " - " -			
Wild flies	Vestigial Wing flies	Black Bodied flies	Vestigial Wing & Black Bodied
Total =	Total =	Total =	Total =

Discussion Questions

1) Complete the following table, which deals with the original **testcross**, between a **heterozygous** individual and a **homozygous mutant** individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **testcross**.

Female phenotype:_____

genotype :_____

Male

GAMETE genotypes   _____   _____   _____   _____

phenotype:

_____   _____

_____   _____

genotype:

_____   _____

_____   _____

3) If the genes we are dealing with were permanently linked and could not separate under any conditions, what would be the expected ratio of Wild : Vestigial : Black : Vestigial & Black flies?

_____:_____:_____:_____

4) How could the flies showing only one mutation arise? (it may be necessary to alter your Punnett Square while answering this question)

_____

_____

_____

_____

5) Using the following equation, determine the linkage distance between the two genes investigated in this experiment.

Linkage Distance = $\dfrac{\textbf{Number of flies with only one mutation}}{\textbf{Total number of flies counted}}$ **X** $\dfrac{\textbf{100}}{\textbf{1}}$

= ─────────── X $\dfrac{100}{1}$

= ─────────── **Units**

6) The actual distance between the vestigial and black genes is 18.5 units. How well did your result compare to the actual linkage distance and how may your results be improved?

_____

_____

_____

_____

7) The longer the distance between the linked genes, the greater the error. Even this distance is much longer than most would wish to measure accurately. Propose a way of more accurately measuring the distance between these two genes. (Hint: there are other genes)

_____

_____

_____

Additional Questions

Additional Questions Continued

Exp 14   Dominant Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of a single dominant gene which governs eye shape in *Drosophila melanogaster* fruit flies. The gene is found on the second chromosome of our flies and normally results in the fly having a wild type eye shape. However, a mutant gene has been found which causes the eye to be smaller, with few facets. This eye shape is called lobe and the gene causing the change in shape is called the Lobe eye gene.

The wild gene, is **recessive** to the **mutant** gene and so a **hybrid** fly, which has both a normal and a mutant gene, would have Lobe eyes. The symbol used for the wild gene is **I** and the mutant **L**.

Wild   Lobe
Eye   Eye

Aim

To examine the inheritance of the single mutant gene for Lobe eye, in three generations of *Drosophila melanogaster* flies.

Procedure

1. Click on the Reset then Select buttons and select Saved Parents.
2. Select **Exp14_f.mfp** or **Exp14_m.mfp.** (f & m are the mutant's sex)
3. Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
4. Click the Breed button and record each offspring's phenotype.
5. During recording, drag a male and female offspring into the Hold Jar.
6. Empty the Parent/Offspring area after counting 50 - 100 offspring.
7. Drag the held flies into the Parent area and breed them before you examine and record them in table 2. They are still offspring until they are bred and so their genotype may not be visible.
8. Record the phenotypes of 200 offspring, then answer the questions.

Results

Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Parent-Cross Results

Parent Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Eyed flies		Lobe Eyed flies	
female	male	female	male
Total =	Total =	Total =	Total =
Total Wild flies =		Total Lobe flies =	

Fly ratio Wild : Lobe _____:_____

Table 2 Hybrid-Cross (F1 Cross) Results

Hybrid Description

Female Phenotype -   Genotype -

Male   "   -   "   -

Wild Eyed flies	Lobe Eyed flies
Total Wild flies =	Total Lobe flies =

Fly ratio Wild : Lobe _____:_____

Discussion Questions

1) Complete the following table, which deals with the original **parent-cross**, between a **homozygous wild** individual and a **homozygous Lobe** eyed individual.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **homozygote-cross** (Parent-cross).

Female
phenotype:_____
genotype :_____

Male
phenotype:
_____
_____
genotype:
_____

GAMETE genotypes _____ _____ _____ _____

3) By referring to the Punnett Square above, what would you expect the ratio of wild flies to Lobe flies to be?

_____ : _____

4) How well does the ratio of **wild : Lobe eyed** flies observed in the experiment compare to the ratio predicted by the Punnett Square? Why?

_____
_____
_____

5) What ratio of wild flies to Lobe eyed flies would you expect if the Lobe mutation was recessive to the wild gene?

_____ : _____

Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

7) Complete the Punnett Square below for the **hybrid-cross** (or F1 cross).

Female
phenotype:_____
genotype :_____

Male
phenotype:
_____
_____
genotype:
_____

GAMETE genotypes _____ _____ _____ _____

From the Punnett Square above, what is the expected ratio of wild flies to Lobe eyed flies?

_____ : _____

What are the expected ratios of genotypes?
(ll : Ll : LL) _____ : _____ : _____

8) How well does the ratio of **wild : Lobe** eyed flies observed in the experiment compare to the ratio predicted by the Punnett Square?

_____

9) How does the dominant nature of the Lobe eye gene affect the second generation phenotypes as compared with if the Lobe eye gene was recessive?

_____
_____

Additional Questions
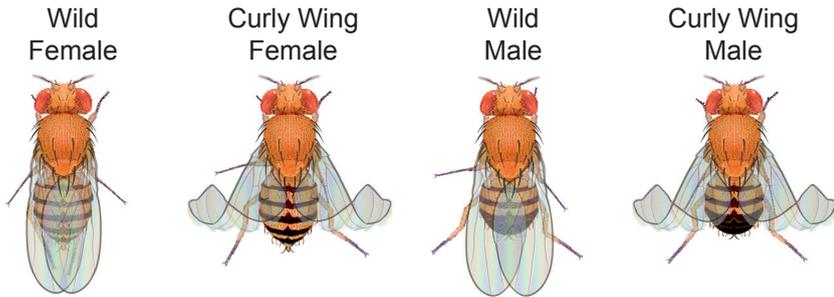
Exp 15   Lethal Gene Inheritance

Name : _____   Date:_____

Introduction

In this experiment we will examine the inheritance of a lethal gene, in *Drosophila melanogaster*. The gene is found on the second chromosome of our flies and normally results in the fly having a flat wing. However, a mutant gene has been found which causes the wing to curl. This wing shape is called curly and the gene causing the change in shape is called the curly wing gene.

The wild gene, is **recessive** to the **mutant** gene and so a **hybrid** fly, which has both a normal and a mutant gene, would have the curly wing shape. The curly gene is **lethal if the fly inherits 2 curly genes** from its parents. The symbol used for the wild gene is **cy** and the mutant **Cy**.

Wild Female	Curly Wing Female	Wild Male	Curly Wing Male

Aim

To examine the inheritance of a lethal gene for curly wing, from two heterozygous individuals, in *Drosophila melanogaster* flies.

Procedure

1.   Click on the Reset then Select buttons and select Saved Parents.
2.   Select **Exp15.mfp**.
3.   Drag each of the parents over to the Observation Platform and record their phenotype and genotype in the first table.
       Both flies will be heterozygous for curly wing.
4.   Click the Breed button and record each offspring's phenotype.
8.   Record the phenotypes of 300 offspring, then answer the questions.

Results   Record the results observed in the following tables, by placing a stroke in the appropriate column, as each offspring is displayed.

Table 1 Hybrid-Cross (F1 Cross) Results

Hybrid Description	
Female Phenotype -	Genotype -
Male " -	" -

Wild Wing flies	Curly Wing flies
Total Wild flies =	Total Curly flies =

Fly ratio Wild : Curly _____:_____

1) Complete the following table, which deals with the **hybrid-cross**, between two **heterozygous** individuals.

Parent	Phenotype	Genotype	Genotypes of gametes
Female			
Male			

2) Complete the Punnett Square below for the **hybrid-cross**.

Female

phenotype:_____

genotype :_____

Male

phenotype:

_____

_____

genotype:

_____

GAMETE genotypes   _____ _____ _____ _____

_____

_____

_____

_____

From the Punnett Square above, what is the expected ratio of wild flies to curly winged flies?

_____ : _____

What are the expected ratios of genotypes?

(cycy : Cycy : CyCy)_____ : _____ : _____

3)   How well does the ratio of **wild : curly** winged flies observed in the experiment compare to the ratio predicted by the Punnett Square?

_____

4)   How does the lethal nature of the curly gene affect the phenotypic ratios of the offspring?

_____

_____

Additional Questions

Trouble Shooting

Program requires Windows XP, ME, 2000 or 98... or Macintosh OSX 10.2 or better.

This program was designed to be run in a 1024 x 768 graphics mode, however, it can be run in any mode greater than this.

Internet access may be required to activate this product.

Periodically check our web site for updates to this program. Free upgrades are available within a whole version number i.e. version 6 to 6.1, 6.2 ....

Please report any problems you might have with this product to: support@newbyte.com

Technical assistance
Where can I obtain further help? For technical support contact:

> Newbyte Educational Software
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> Email: support@newbyte.com
> Web Site: www.newbyte.co.uk

Please write down your:
- *   Product Key Code
- *   problem and any steps taken to relieve the problem
- *   computer make and model, for example, IBM Pentium lll
- *   Operating System e.g. Windows XP, Me, 2000... or Mac OSX
- *   include the message on the screen, e.g. Not Enough Memory or installation error codes.