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Fruit Fly Genetics Simulation

Activity Kit

Introduction

Explore how the appearance of an organism relates to its genetic makeup using this interactive Fruit Fly Genetics card simulation.

Concepts

- *Drosophila* life cycle
- Sex-linked traits
- Genotype vs. phenotype
- Punnett squares
- Dominant and recessive traits

Background

Genetics is the scientific study of heredity. Scientists substitute simple organisms for humans when studying inherited diseases and disorders. About 60% of the genes that are known to cause human disease have a recognizable match in the genetic code of the common fruit fly (*Drosophila melanogaster*), and 50% of *Drosophila*'s protein sequences are similar to those of mammals. Fruit flies are commonly used in genetic research because these gene and protein similarities are contained in an organism with only four pairs of chromosomes—the X/Y sex chromosomes and three autosomes, numbered 2, 3 and 4. The four pairs of chromosomes contain 132 million base pairs of DNA, comprising 13,676 genes. For comparison, the human genome has 3.2 billion base pairs, which make up 20,500 genes on 23 chromosomes. Other advantages to using *Drosophila* are that they breed and mature rapidly, are inexpensive and easy to raise, produce several hundred offspring per generation, and require very little space. The fruit fly is also an ideal candidate for genetic studies because simple mutations cause obvious phenotype (the outward appearance of an organism) differences, and its genome map has been fully sequenced (completed in 2000).

Genes are sections of a chromosome that code for individual proteins. A trait is defined as a physical characteristic that can be passed from parent to offspring. Alternate forms of a gene are called *alleles*. Most organisms have two copies of every gene, one inherited on the chromosome from the mother and one on the chromosome inherited from the father. Individuals carrying two identical versions or alleles of a given gene, which may be either AA or aa, are said to be *homozygous* for the gene. Similarly, when two different alleles are present in a gene pair, labeled Aa, the individual is said to have a *heterozygous* genotype. The homozygous dominant genotype (AA) and the heterozygous genotype (Aa) will both show dominant phenotypes (because A is dominant to a) whereas the homozygous recessive genotype (aa) will exhibit a recessive phenotype. These rules apply not only for a single characteristic or traits resulting from a monohybrid cross, but also for a dihybrid cross in which two genes associated with different traits with contrasting characteristics are considered. A special case exists for genes on the sex chromosomes. Since the Y chromosome contains very few genes, the only copy of a gene in a male resides on the X chromosome which may cause a recessive gene to be expressed even though there is only one copy of the gene present. Sex-linked inheritance occurs mostly in males because a female has two copies of the X chromosome and therefore her genotype will follow normal inheritance rules.

Drosophila Characterization

Like all insects, *Drosophila* have three main body parts: the head, the thorax, and the abdomen (see Figure 1). The major structures on the head of a wild-type fruit fly are the large red compound eyes. There are also two antennae on top of the fly's head used for smelling. The mouth is a proboscis—the fly lowers it to suck up food like a vacuum cleaner. The thorax has six legs, two wings and, on the dorsal (top) side, a number of long dark bristles. Females have stripes on every segment of their abdomen. Males have shorter abdomens, and the last few segments of the abdomen are solid black. Males also have a set of brown anal plates on the ventral (bottom) side of the abdomen (see Figure 2).

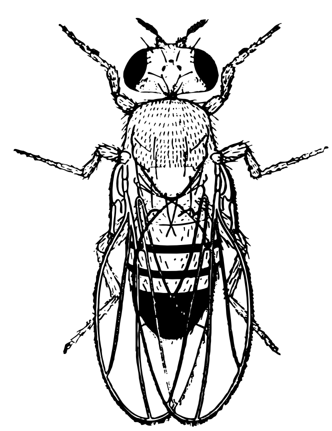

Figure 1. *Drosophila*

Sexing Flies

In selecting flies for genetic mating, it is absolutely essential that the sex of each fly be properly identified. Identification of sex is most reliably done by examination of the genital organs with the aid of magnification, using a stereoscope. The external reproductive organs of both the male and the female are located on the ventral, posterior part of the abdomen (see Figure 2). The male genitalia are surrounded by heavy, dark bristles that are not found on the female. This characteristic is quite distinct even in a fly that has just emerged from the puparium. Female genitalia are seen as a small bump on the end of the abdomen. The posterior part of the abdomen is quite dark in males and considerably lighter in females. The tip of the abdomen is also rounded in males and more pointed in females. Male fruit flies tend to be smaller than females.

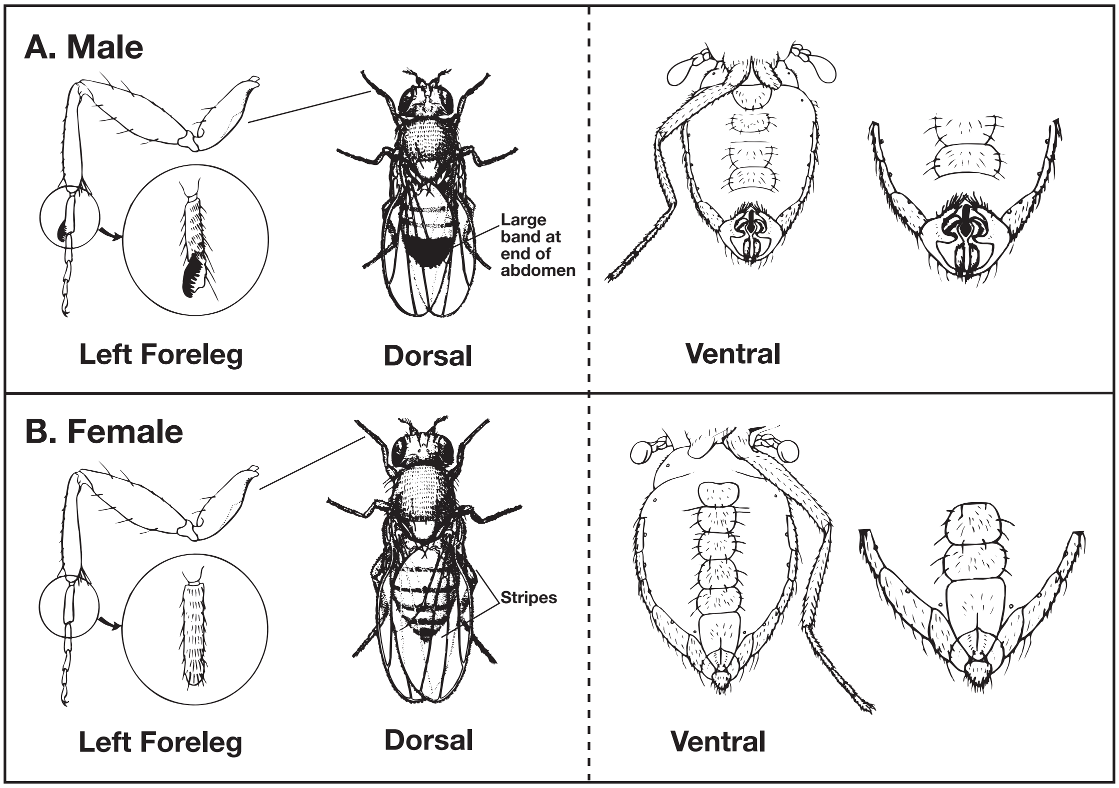

Figure 2. Dorsal and Ventral View of *Drosophila*

With practice and care, the front legs can also be used to distinguish the sexes. There are sex combs on the front legs of the male fly (used for grasping the female).

Drosophila Mutations

The wild-type fruit fly has full wings, red eyes, and brownish-tan coloring, along with bristles and antennae. There are many trait mutations available for crossing. Most mutations involve a change in the eyes, wings, bristles or antennae. The changes may be the complete absence of the feature, such as no eyes, a change in shape, such as bar-shaped eyes, or a change in color, such as white eyes. Each mutant type is given a name suggesting the main distinguishing feature. The name is usually a descriptive adjective, such as "black," or a noun, such as "bar." For convenience in listing and labeling, a representative symbol is assigned to each mutant type. By convention, if the trait is recessive it is listed as lower case letter(s), while dominant traits are listed as uppercase letter(s). Wild-type is designated by a plus sign (+). See Table 1 for a list of common trait mutations in *Drosophila*.

Trait	Symbol	Dominant or Recessive	Description	Chromosome #
Bar	B	Dominant	Eyes are restricted vertically to a narrow bar in males and in homozygous females.	X
White	w	Recessive	Eyes are a distinctive white in color.	X
Yellow	y	Recessive	Body color is yellow.	X
Apterous	ap	Recessive	Wings are absent.	2
Black	b	Recessive	Black color on the ends of the legs, wing veins, and the body. Pigmentation darkens with age.	2
Dumpy	dp	Recessive	Wings shortened 25%, to approximately the length of the body.	2
Lobe	L	Dominant	Eyes greatly reduced in size, with indentation at anterior edge.	2
Vestigial	vg	Recessive	Stumpy, underdeveloped wings.	2
Ebony	e	Recessive	Body color is shiny black.	3
Sepia	se	Recessive	Red-brown eyes at emergence darken to sepia and ultimately to black as the fly ages.	3

Table 1. Common *Drosophila* Mutations

Punnett Squares

Punnett squares will be used in this activity to determine the gene combinations that might result from *Drosophila* crossings. A sample Punnett square for a monohybrid cross between a dumpy female (dp/dp) and a wild-type male (+/+) is shown in Figure 3 below. Notice how the gametes are individually represented in the Punnett square. In this cross, all of the resulting phenotypes are wild-type flies.

P	dp/dp	+/+
Gametes	+	+
dp	dp/+	dp/+
dp	dp/+	dp/+

Figure 3.

In a dihybrid cross, two pairs of contrasting characteristics are compared simultaneously. For example, a heterozygous non-vestigal winged female with non-ebony body color ($vg^+/vg\ e^+/e$) is crossed with a heterozygous male with non-vestigal wings and non-ebony body color ($vg^+/vg\ e^+/e$). In the dihybrid cross represented above, four possible gamete combinations (vg^+e^+, vg^+e, vge^+, and vge) would be placed in a four-column by four-row Punnett square and crossed with one another to find the resulting offspring.

Experiment Overview

In this activity, five different types of genetic crosses of fruit flies will be simulated—a monohybrid cross, a backcross, a dihybrid cross and two sex-linked crosses. Two generations of fruit fly crosses will be performed and their genotypes documented. Using these genotypes, the phenotype of the flies will be determined and visually represented using Fruit Fly Genetics Cards. The genotypic and phenotypic ratios will then be investigated.

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

1. Describe the differences between a male and female fruit fly.
2. What are the distinguishing traits of wild type, sepia, ebony, and dumpy flies?

Materials

Fruit Fly Genetics Card Deck
Monohybrid Cross Sheet
Backcross Sheet
Dihybrid Cross Sheet Set
Sex-Linked Cross I Sheet
Sex-Linked Cross II Sheet

Procedure

Part I. Monohybrid Cross

1. Obtain a deck of Fruit Fly Genetics Cards and the Monohybrid Cross Sheet.
2. A monohybrid cross will be simulated as a wild type (+) male fly will be crossed with a virgin female sepia fly (se). The genotype symbol for this parent (P) fly cross is written as se/se and +/+. The parent fly genotype symbols are already provided on the Monohybrid Cross Sheet.
3. The cards from the Fruit Fly Genetics Card Deck represent the phenotypes of the flies. Locate a female sepia Fruit Fly Card and a male wild type Fruit Fly Card from the Fruit Fly Genetics Card deck. Use the information from the *Background* section to help identify these cards.
4. Place these cards on the P squares of the Monohybrid Cross Sheet.
5. Record the corresponding gamete symbols in the Punnett square headers below the P generation. The gamete for each header of the Punnett square is simply one-half of each parent's genotype symbol. For example, the male wild type fly will have a + in each of the top two empty gamete boxes.
6. Complete this cross by writing in the genotype for each gamete combination in the four squares below the parent cards. The resulting genotype(s) represent the F1 generation.
7. Locate the corresponding Fruit Fly Cards for each F1 genotypes. The fruit fly cards may be male or female. Place the correct cards over each written genotypes for the F1 generation. Remember that the wild type gamete + is dominant. These cards represent the F1 phenotypes.
8. Cross an F1 female (would be virgin in an actual cross) with an F1 male. Record the genotype symbols for each of these flies next to the F1 Parents boxes.
9. Place a male Fruit Fly Card and female Fruit Fly Card from the F1 generation from step 7 on each of the F1 parent genotype symbols.
10. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
11. Complete this cross by writing in the genotype for each gamete combination in the four squares below the F1 parent cards. The resulting genotype(s) represent the F2 generation.
12. Locate and place the correct Fruit Fly Cards for each of the resulting F2 genotypes. The fruit fly cards may be male or female. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.
13. Answer the Questions for Part I on the Fruit Fly Genetics Question Sheet.
14. Return all of the cards to the Fruit Fly Genetics Card Deck.

Part II. Backcross

1. Obtain the Backcross Sheet and a deck of Fruit Fly Genetics Cards.
2. Repeat steps 2–6 from Part I on the Backcross Sheet.
3. Cross an F1 male with a sepia female (would be a virgin female in an actual cross). Record the genotype symbol for each fly next to the F1 parent boxes.
4. Place a male F1 generation Fruit Fly Card and sepia female Fruit Fly card on each of the F1 parent genotype symbols.
5. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
6. Complete this cross by writing in the genotype for each gamete combination in the four squares below the F1 parent cards. The resulting genotype(s) represent the F2 generation.
7. Locate and place the corresponding Fruit Fly Cards for each of the F2 genotypes. The fruit fly cards may be male or female. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.
8. Answer the Questions for Part II on the Fruit Fly Genetics Question Sheet.
9. Return all of the cards to the Fruit Fly Genetics Card Deck.

Part III. Dihybrid Cross

1. Obtain the Dihybrid Cross Sheets and a deck of Fruit Fly Genetics Cards.
2. In this cross, the inheritance of two pairs of contrasting characteristics will be compared. A dihybrid cross between virgin dumpy (short-winged) females with normal (non-ebony) body color (dp/dp e^+/e^+) will be crossed with males with normal wings (non-dumpy) and ebony body color (dp^+/dp^+ e/e). These parent fly genotype symbols are already provided on the Dihybrid Cross Sheet.
3. Locate a female dumpy, non-ebony card and a male non-dumpy, ebony card from the Fruit Fly Genetics Card deck.
4. Place these cards on the P squares of the Dihybrid Cross Sheet.
5. Record the corresponding gamete symbols in the Punnett square headers below the P generation on the Dihybrid Cross Sheet. The gamete for each header of the Punnett square is simply one-half of each parent's genotype symbol. For example, the male non-dumpy, ebony fly will have a dp e+ in one of the gamete boxes.
6. Complete this cross by writing in the genotype for the square below the parent cards. The resulting genotype represents the F1 generation. *Note:* Only one gamete combination is possible.
7. Locate a Fruit Fly Card for the resulting F1 genotype. This card represents the F1 phenotype of all of the flies for this cross. This card may either be female or male. Place the card over the written genotype for the F1 generation.
8. Obtain another F1 generation Fruit Fly Card with the same traits as the fly from step 7 only of the opposite sex.
9. Cross an F1 female (would be virgin in an actual cross) with an F1 male. Record the genotype symbols for each of these flies next to the F1 Parents boxes on the Dihybrid Cross Sheet.
10. Place the male Fruit Fly Card and female Fruit Fly Card from the F1 generation from steps 7 and 8 on each of the F1 parent genotype symbols.
11. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
12. Complete this cross by writing in the genotype for each gamete combination in the sixteen squares below the F1 parent cards. The resulting genotypes represent the F2 generation.
13. Locate and place the correct Fruit Fly Cards for each of the resulting F2 genotypes. The fruit fly cards may be male or female. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.
14. Answer the Questions for Part III on the Fruit Fly Genetics Question Sheet.
15. Return all of the cards to the Fruit Fly Genetics Card Deck.

Part IV. Sex-Linked Cross I

1. Obtain a deck of Fruit Fly Genetics Cards and the Sex-Linked Cross I Sheet.
2. A sex-linked cross will be simulated for a wild type, red-eyed, virgin female fly (x^+x^+) will be crossed with a white-eyed male fly (x^wy). The parent fly genotype symbols are already provided on the Sex-Linked Cross I Sheet.
3. Locate a female wild type, red-eyed card and a male white-eyed card from the Fruit Fly Genetics Card deck.
4. Place these cards on the P squares of the Sex-Linked Cross I Sheet.
5. Record the corresponding gamete symbols in the Punnett square headers below the P generation.
6. Complete this cross by writing in the genotype for each of the four squares below the parent cards. The resulting genotype(s) represent the F1 generation.
7. Locate the correct Fruit Fly Cards for each of the resulting F1 genotypes. Place the correct cards over the written genotypes for the F1 generation. These cards represent the F1 phenotypes.
8. Cross an F1 female (would be virgin in an actual cross) with an F1 male. Record the genotype symbols for each of these flies next to the F1 Parents boxes.
9. Place a male Fruit Fly Card and female Fruit Fly card from the F1 generation from step 7 on each of the F1 parent genotype symbols.

10. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
11. Complete this cross by writing in the genotype for each gamete combination in the four squares below the F1 parent cards. The resulting genotype(s) represent the F2 generation.
12. Locate and place the correct Fruit Fly Cards for each of the resulting F2 genotypes. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.
13. Answer the Questions for Part IV on the Fruit Fly Genetics Question Sheet.
14. Return all of the cards to the Fruit Fly Genetics Card Deck.

Part V. Sex-Linked Cross II

1. Obtain a deck of Fruit Fly Genetics Cards and the Sex-Linked Cross II Sheet.
2. A sex-linked cross will be simulated for a white-eyed, virgin female fly (x^wx^w) will be crossed with a wild type, red-eyed male fly (x^+y). The parent fly genotype symbols are already provided on the Sex-Linked Cross I Sheet.
3. Locate a female white-eyed card and a male wild type, red-eyed card from the Fruit Fly Genetics Card deck.
4. Place these cards on the P squares of the Sex-Linked Cross II Sheet.
5. Record the corresponding gamete symbols in the Punnett square headers below the P generation.
6. Complete this cross by writing in the genotype for each gamete combination in the four squares below the parent cards. The resulting genotype(s) represent the F1 generation.
7. Locate the correct Fruit Fly Cards for each of the F1 genotypes. Place the correct cards over the written genotypes for the F1 generation. These cards represent the F1 phenotypes.
8. Cross an F1 female (would be virgin in an actual cross) with an F1 male. Record the genotype symbols for each of these flies next to the F1 Parent boxes.
9. Place a male Fruit Fly Card and female Fruit Fly card from the F1 generation from step 7 on each of the F1 parent genotype symbols.
10. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
11. Complete this cross by writing in the genotype for each gamete combination in the four squares below the F1 parent cards. The resulting genotype(s) represent the F2 generation.
12. Locate and place the correct Fruit Fly Cards for each of the resulting F2 genotypes. Place the correct cards over the written genotypes for the F2 generation. These cards represent the F2 phenotypes.
13. Answer the Questions for Part V on the Fruit Fly Genetics Question Sheet.
14. Return all of the cards to the Fruit Fly Genetics Deck.

Name: ________________________________

Fruit Fly Genetics Questions

Part I. Monohybrid Cross

1. Why is it crucial to use virgin female flies in genetic crosses?

2. What is the resulting phenotypic ratio for the F1 generation flies?

3. What is the resulting phenotypic ratio for the F2 generation flies?

4. If forty F2 flies from this simulation were actually crossed, theoretically how many of the flies would be wild type? How many would theoretically be sepia?

Part II. Backcross

1. What is the resulting phenotypic ratio for the F1 generation flies?

2. What is the resulting phenotypic ratio for the F2 generation flies?

3. How does the Backcross differ from the Monohybrid cross performed in Part I?

4. (Optional) What is the benefit of performing a backcross?

Part III. Dihybrid Cross

1. What is the resulting phenotypic ratio for the F1 generation flies?

2. What is the resulting phenotypic ratio for the F2 generation flies?

3. If eighty F2 flies from this simulation were actually crossed, theoretically how many of the flies would be:
   a. non-ebony and non-dumpy

   b. ebony and non-dumpy

   c. non-ebony and dumpy

   d. ebony and dumpy

Part IV. Sex-Linked Cross I

1. What is the resulting phenotypic ratio for the F1 generation flies?

2. What is the resulting phenotypic ratio for the F2 generation flies?

3. How does a sex-linked cross differ from the crosses in Parts I, II, and III?

Part V. Sex-Linked Cross II

1. What is the resulting phenotypic ratio for the F1 generation flies?

2. What is the resulting phenotypic ratio for the F2 generation flies?

3. Describe the differences between the Sex-Linked I and Sex-Linked II crosses.

Teacher's Notes
Fruit Fly Genetics

Materials Included in Kit (for 5 groups of students)

Fruit Fly Genetics Card Decks, 5
Monohybrid Cross Sheets, 5
Backcross Sheets, 5
Dihybrid Cross Sheet Sets, 5
Sex-Linked Cross I Sheets, 5
Sex-Linked Cross II Sheets, 5

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement

Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard C: Life Science, structure and function in living systems, reproduction and heredity, population and ecosystems, diversity and adaptations of organisms

Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard C: Life Science, molecular basis of heredity, biological evolution

Teaching Tips

- Enough materials are provided in this kit for 30 students working in groups of 6, or for 5 groups of students. All materials are reusable. This laboratory activity can reasonably be completed in one 50-minute class period. The pre-laboratory assignment may be completed before coming to lab.
- Students should have a knowledge of Punnett squares before beginning this activity. Have students consult their textbooks for more information regarding Punnett squares if necessary.
- Sepia flies have red-brown eyes at emergence that darken to sepia and ultimately to black as the fly ages. The sepia fruit fly cards given in this activity have sepia-colored (dark brown) eyes.
- Not all of the *Drosophila* mutations presented in the chart in the *Background* section are present in this activity. Have students research other possible *Drosophila* mutations and perform sample crosses.
- *Drosophila* pass through four distinct phases of development: egg, larva, pupa, and adult (see Figure 2). The time spent in each phase varies with temperature because insects are *poikilothermic,* or "cold-blooded." At 21–25 °C a new generation will grow from egg to adult in 12–14 days, while at 18 °C the generation time is 20–24 days. At room temperature, a typical generation time is 12 days and it includes the following stages. The day after an egg is laid a larva hatches from the egg. The larva molts twice, shedding the cuticle, mouth hooks, and spiracles. During the periods of growth before and after molting, the larva is called an *instar*. The fruit

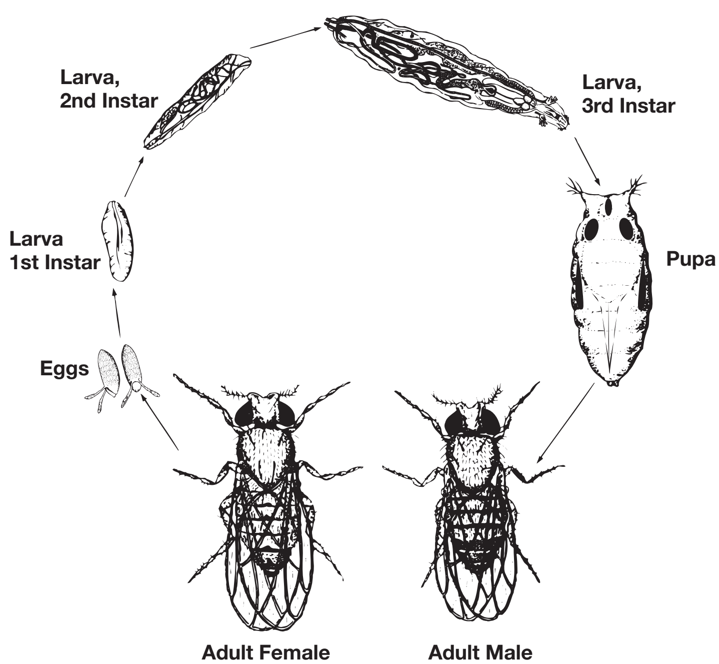

Figure 2. *Drosophila* Life Cycle

fly has three instars. The first two each last about one day while the third and final instar lasts about two days. Each larva form feeds by burrowing through the media. About 120 hours after the egg was laid, the final instar larva crawls out of the media for pupariation. The cuticle of the larva hardens to form the puparium.

The puparium contains the fruit fly as it undergoes metamorphosis into an adult fly. As the pupa matures, it becomes dark in color. About one day before emergence, the folded wings appear as two dark elliptical bodies, and the pigment of the large eyes becomes visible through the puparium. When metamorphosis is complete, the adult emerges by forcing its way through the anterior end of the puparium. The newly emerged fly is pale in color, its shape is elongated, and the wings are unexpanded. In a few hours the adult matures, developing its characteristic color and shape, and within 10 hours it is capable of mating. The adult fruit fly may live for several weeks.

- This is a great activity to introduce to students before they perform actual live *Drosophila* genetic crossings. Flinn Scientific sells all of the essentials required for live *Drosophila* experiments:

Flinn Cat. No.	**Description**
LM1115	*Drosophila,* Wild-type
LM1117	*Drosophila,* white
LM1121	*Drosophila,* dumpy
LM1124	*Drosophila,* ebony
LM1125	*Drosophila,* sepia
FB1438	Lull-A-Fly Kit
FB0751	*Drosophila,* Laboratory Kit

- Explain to students that the activities performed in this lab are just simulations. The results of actual *Drosophila* crosses may vary.

Answers to Pre-Lab Questions *(Student answers will vary.)*

1. Describe the differences between a male and female fruit fly.

   The male genitalia are surrounded by heavy, dark bristles that are not found on the female. Female genitalia are seen as a small bump on the end of the abdomen. The posterior part of the abdomen is quite dark in males and considerably lighter in females. Males have sex combs on their front legs. The tip of the abdomen is also rounded in males and more pointed in females. Male fruit flies tend to be smaller than females.

2. What are the distinguishing traits of wild type, sepia, ebony, and dumpy flies?

   Wild-type flies have red eyes, long wings, brownish-tan coloring.
   Sepia flies have dark brown eyes.
   Ebony flies have shiny black bodies.
   Dumpy flies have short wings.

Sample Worksheet

Part I. **P** se/se x +/+

Gametes	+	+
se	se/+	se/+
se	se/+	se/+

F_1 Phenotypes—all wild

F_1 se/+ x se/+

Gametes	se	+
se	se/se	se/+
+	se/+	+/+

F_2 Phenotypes—3 wild : 1 sepia

Part II. **P** se/se x +/+

Gametes	+	+
se	se/+	se/+
se	se/+	se/+

F_1 Phenotypes—all wild

F_1 se/+ x se/se

Gametes	se	se
se	se/se	se/se
+	se/+	se/+

F_2 Phenotypes—1 wild : 1 sepia

Part III. **P** $dp/dp\ \ e^+/e^+$ x $dp^+/dp^+\ \ e/e$

Gametes	$dp^+\ \ e$
$dp\ \ e^+$	$dp^+/dp\ \ e^+/e$

F_1 Phenotypes—all heterozygous, non-ebony, non-dumpy

F_1 $dp^+/dp\ \ e^+/e$ x $dp^+/d\ \ e^+/e$

Gametes	dp^+e^+	dp^+e	dpe^+	dpe
dp^+e^+	$dp^+/dp^+\ \ e^+/e^+$	$dp^+/dp^+\ \ e^+/e$	$dp^+/dp\ \ e^+/e^+$	$dp^+/dp\ \ e^+/e$
dp^+e	$dp^+/dp^+\ \ e^+/e$	$dp^+/dp^+\ \ e/e$	$dp^+/dp\ \ e^+/e$	$dp^+/dp\ \ e/e$
dpe^+	$dp^+/dp\ \ e^+/e^+$	$dp^+/dp\ \ e^+/e$	$dp/dp\ \ e^+/e^+$	$dp/dp\ \ e^+/e$
dpe	$dp^+/dp\ \ e^+/e$	$dp^+/dp\ \ e/e$	$dp/dp\ \ e^+/e$	dp/dp e/e

F_2 Phenotypes—
- 9 non-ebony, non-dumpy;
- 3 ebony, non-dumpy;
- 3 non-ebony, dumpy;
- 1 ebony, dumpy

Part IV.

P x^+x^+ x x^wy

Gametes	x^w	y
x^+	x^+x^w	x^+y
x^+	x^+x^w	x^+y

F_1 Phenotypes—all flies red-eyed regardless of sex

F_1 x^+x^w x x^+y

Gametes	x^+	y
x^+	x^+x^+	x^+y
x^w	x^+x^w	x^wy

F_2 Phenotypes—2 red-eyed females: 1 red-eyed male: 1 white-eyed male. (*Note:* There are no white-eyed females possible.)

Teacher's Notes *continued*

Part V.

P $x^w x^w$ x $x^+ y$

Gametes	x^+	y
x^w	x^+x^w	$x^w y$
x^w	x^+x^w	$x^w y$

F_1 Phenotypes—1 red-eyed female: 1 white-eyed male

F_1 x^+x^w x $x^w y$

Gametes	x^w	y
x^+	x^+x^w	$x^+ y$
x^w	$x^w x^w$	$x^w y$

F_2 Phenotypes—1 red-eyed male: 1 white-eyed male: 1 red-eyed female: 1 white-eyed female

Sample Answers to Fruit Fly Genetics Question Sheet *(Student data will vary.)*

Part I. Monohybrid Cross

1. Why is it crucial to use virgin female flies in genetic crosses?

   If virgin flies are not used, the genetic results could be skewed as the correct parent generation may not be identified.
2. What is the resulting phenotype for the F1 generation flies?

   All flies are wild type.
3. What is the resulting phenotypic ratio for the F2 generation flies?

   3 wild-type : 1 sepia.
4. If forty F2 flies from this simulation were actually crossed, theoretically how many of the flies would be wild type? How many would theoretically be sepia?

   There would theoretically be 30 wild-type flies and 10 sepia flies.

Part II. Backcross

1. What is the resulting phenotype for the F1 generation flies?

   All flies are wild-type.
2. What is the resulting phenotypic ratio for the F2 generation flies?

   1 wild-type : 1 sepia.
3. How does the Backcross differ from the Monohybrid cross performed in Part I?

   The backcross is different from the monohybrid cross because a recessive fly was crossed with one of the F1 generation flies. This resulted in a 1:1 ratio of wild-type to sepia flies as compared to the 3:1 ratio found in the Monohybrid cross.
4. (Optional) What is the benefit of performing a backcross?

   A backcross may be performed to determine if a dominantly-expressed phenotype is homozygous or heterozygous.

Part III. Dihybrid Cross

1. What is the resulting phenotype for the F1 generation flies?

   All of the flies are heterozygous, non-ebony and non-dumpy.
2. What is the resulting phenotypic ratio for the F2 generation flies?

   The resulting phenotypic ratio is as follows:
   9 non-ebony, non-dumpy
   3 ebony, non-dumpy
   3 non-ebony, dumpy
   1 ebony, dumpy

3. If eighty F2 flies from this simulation were actually crossed, theoretically how many of the flies would be:
   a. non-ebony and non-dumpy
   45
   b. ebony and non-dumpy
   15
   c. non-ebony and dumpy
   15
   d. ebony and dumpy
   5

Part IV. Sex-Linked Cross I

1. What is the resulting phenotypic ratio for the F1 generation flies?
   All red-eyed regardless of sex.
2. What is the resulting phenotypic ratio for the F2 generation flies?
   2 red-eyed females: 1 red-eyed male : 1 white-eyed male. No white-eyed females are possible.
3. How does a sex-linked cross differ from the crosses in Parts I, II, and III?
   Sex-linked traits are unique in that they are restricted to the X and Y chromosomes. Since the Y chromosome contains very few genes, the only copy of a gene in a male resides on the X chromosome which may cause a recessive gene to be expressed even though there is only one copy of the gene present. Sex-linked inheritance occurs mostly in males because a female has two copies of the X chromosome and therefore her genotype will follow normal inheritance rules.

Part V. Sex-Linked Cross II

1. What is the resulting phenotype for the F1 generation flies?
   1 red-eyed female : 1 white-eyed male.
2. What is the resulting phenotypic ratio for the F2 generation flies?
   1 red-eyed-male : 1 white-eyed male : 1 red-eyed female : 1 white-eyed female.
3. Describe the differences between the Sex-Linked I and Sex-Linked II crosses.
   The changes in the sexes and traits of the parent flies from Sex-Linked Cross I and Sex-Linked Cross II changed the phenotypic ratios and the sexes of the F1 and F2 generations as stated in the answers for questions 1 and 2 of Parts IV and V.

The *Fruit Fly Genetics Simulation—Super Value Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
FB1912	Fruit Fly Genetics Simulation—Super Value Kit
LM1115	*Drosophila,* Wild-type
LM1117	*Drosophila,* white
LM1123	*Drosophila,* vestigial
LM1120	*Drosophila,* black-body
LM1125	*Drosophila,* sepia
FB1438	Lull-A-Fly Kit
FB0751	*Drosophila* Laboratory Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.