Drosophila Genetics Simulation

Introduction

Explore how the appearance of an organism relates to its genetic makeup using this interactive *Drosophila* Genetics card simulation. Simulate a monohybrid genetic cross between wild-type and sepia fruit flies.

Concepts

- Genotype vs. phenotype
- Monohybrid cross

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 on page 2).

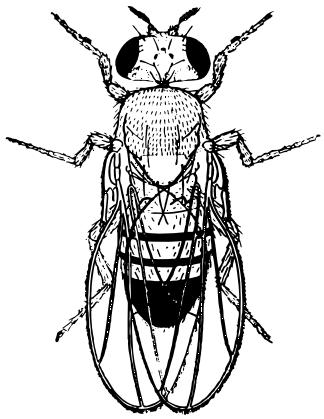

Figure 1. *Drosophila*

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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.

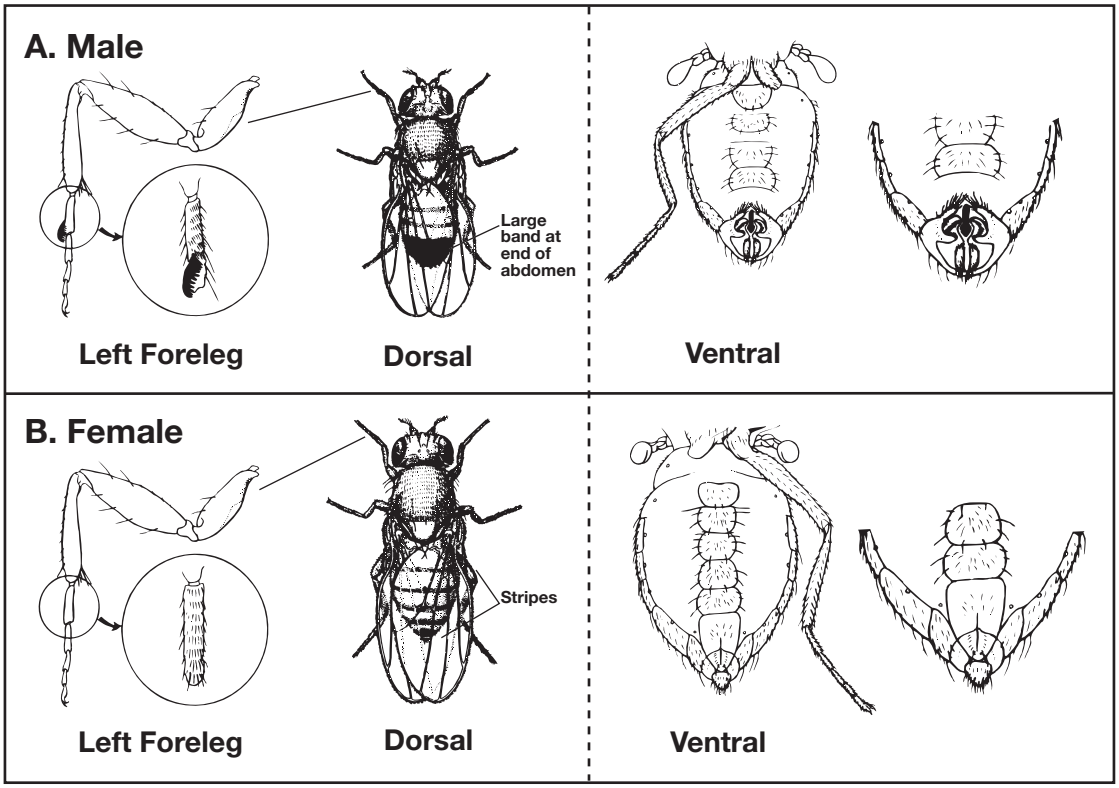

Figure 2. Dorsal and Ventral View of *Drosophila*

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 lowercase 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*.

Table 1. Common *Drosophila* Mutations

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

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 nonvestigal 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.

Materials

Fruit Fly Genetics Card Deck

Monohybrid Cross Sheet

Safety Precautions

This classroom activity is considered nonhazardous. Follow all standard classroom safety guidelines.

Procedure

Part I. Monohybrid Cross

1. 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.
2. 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.

3. Place these cards on the P squares of the Monohybrid Cross Sheet.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. Record the corresponding gamete symbols in the Punnett square headers below F1 parent cards.
10. 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.
11. 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 phen types.

Disposal

The cards used in this activity may be saved and stored for future use.

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, populations and ecosystems, diversity and adaptations of organisms
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard C: Life Science, the cell, molecular basis of heredity, biological evolution, interdependence of organisms; matter, energy, and organization in living systems

The *Drosophila Genetics Simulation* is available from Flinn Scientific, Inc.

Catalog No.	Description
FB1912	*Drosophila* Genetics Simulation

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