

INVESTIGATION 12

FRUIT FLY BEHAVIOR

What environmental factors trigger a fruit fly response?

■ BACKGROUND

Drosophila melanogaster, the common fruit fly, is an organism that has been studied in the scientific community for more than a century. Thomas Hunt Morgan began using it for genetic studies in 1907. The common fruit fly lives throughout the world and feeds on fruit and the fungi growing on rotting fruit. It is a small fly, and one could question why scientists have spent so much time and effort on this tiny insect. It is about the size of President Roosevelt's nose on a dime, but despite its small size, the fly is packed with many interesting physical and behavioral characteristics. Its genome has been sequenced, its physical characteristics have been charted and mutated, its meiotic processes and development have been investigated, and its behavior has been the source of many experiments. Because of its scientific usefulness, *Drosophila* is a model research organism. Its name is based on observations about the fly; the fly follows circadian rhythms that include sleeping during the dark and emerging as an adult from a pupa in the early morning. This latter behavior gave rise to the name *Drosophila*, which means "lover of dew." The explanation for the species name *melanogaster* should be clear after observing the fly's physical features. It has a black "stomach," or abdomen. No doubt the dew-loving, black-bellied fly will continue to make contributions to the scientific community and to student projects.

We begin our investigation with a few simple questions. What do you know about fruit flies? Have you seen fruit flies outside the lab and, if so, where? Describe where and when you have noted fruit flies.



■ Learning Objectives

- To investigate the relationship between a model organism, *Drosophila*, and its response to different environmental conditions
- To design a controlled experiment to explore environmental factors that either attract or repel *Drosophila* in the laboratory setting
- To analyze data collected in an experiment in order to identify possible patterns and relationships between environmental factors and a living organism
- To work collaboratively with others in the design and analysis of a controlled experiment
- To connect and apply concepts (With the fruit fly as the focal organism, your investigation could pull together many topics, such as genetics, animal behavior, development, plant and animal structures from cells to organs, cell communication, fruit ripening, fermentation, and evolution.)

■ General Safety Precautions

- Do not add substances to the choice chamber unless your teacher has approved them.
- If the substance you add is flammable, such as ethanol, use precaution and do not conduct your experiment near a heat source or flame.
- Many of the substances used in this experiment are food items, but you should not consume any of them.
- Fruit flies are living organisms that should not be released to the environment. After all the investigations are complete, flies should be tapped into a “morgue” through a funnel. The morgue typically is a 150-mL beaker that contains about 50 mL of salad oil or 70% alcohol.

THE INVESTIGATIONS

Getting Started

This procedure is designed to help you understand how to work with fruit flies. You may start with general information about how to determine the sex of a fruit fly. How do you tell the difference between male and female flies? Is the sex of the fly important to your investigations? Look at the female and male fruit flies in Figure 1. Then look at the fruit flies in Figure 2. Can you identify which ones are female and which ones are male? Focus on the abdomen of the flies to note differences.

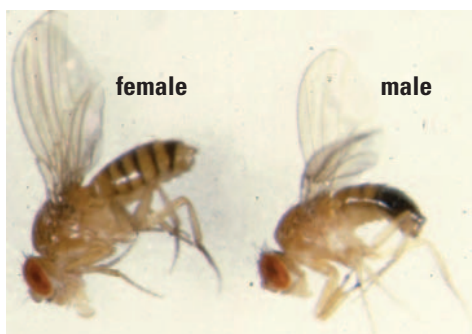


Figure 1. Determining the Sex of Fruit Flies



Figure 2. Fruit Flies

Step 1 Using fruit fly cultures, carefully toss 10 to 20 living flies into an empty vial. Be sure to plug the vial as soon as you add the flies. Do not anesthetize the flies before this or any of the behavior experiments.

Step 2 When flies are tossed, they are tapped into an empty vial. Tap a culture vial (push the vial down on a solid surface several times) on the table to move the flies to the bottom of the vial. Quickly remove the foam or cotton top and invert an empty vial over the top of the culture vial. Invert the vials so that the culture vial is on the top and the empty vial is on the bottom, and tap the flies into the empty container by tapping it on a solid surface several times. Be sure to hold the vials tightly to keep them together. You must then separate the vials and cap each separately. Do not try to isolate every fly from the original culture. It is difficult to separate flies, and you may lose a fly or two in the process.

Step 3 After your lab group has the flies in a vial without food, observe the position of the flies in your upright vial.

Step 4 Invert the vial, and observe the position of the flies after 15 seconds and after 30 seconds.

Step 5 What was the flies' response? Did most/all of the flies move in the same general direction? If so, this might be an "orientation movement," which is a movement that is in response to some stimulus. Based on how you manipulated the vial, to what stimulus might the flies be responding? Do you think that they were responding to some chemical change in the vial? Did your observations generate other questions? Explain your answers.

■ Procedure

Animals move in response to many different stimuli. A chemotaxis is a movement in response to the presence of a chemical stimulus. The organism may move toward or away from the chemical stimulus. What benefit would an organism gain by responding to chemicals in their environment? A phototactic response is a movement in response to light. A geotactic response is a movement in response to gravity.

You will investigate fruit fly movement using a choice chamber that exposes the flies to different substances that you insert into the chamber. Because flies are very common in households (in fact, fruit flies live almost everywhere that humans live), think about using foods or condiments that might result in a positive or a negative chemotactic response from the flies. What foods or condiments do you think would attract or repel flies? Why? Do fruit flies exhibit a response to light or to gravity? How can you alter the chamber to investigate those variables?

Step 1 Prepare a choice chamber by labeling both ends with a marker — one end "A" and the other "B" (see Figure 3). Cut the bottom of the bottles, dry the interior thoroughly, and tape them together. Remove any paper labels.

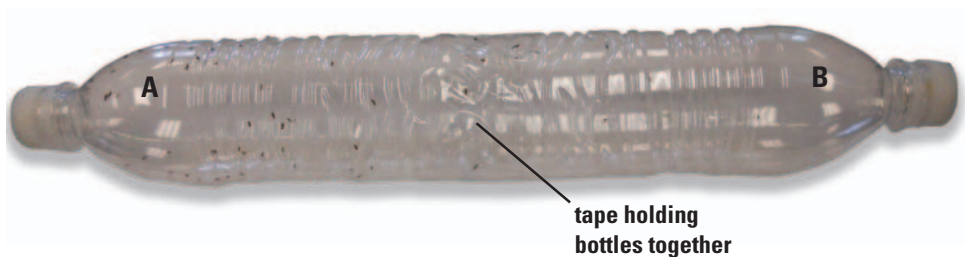


Figure 3. Choice Chamber

Place a cap on one end of a chamber before adding flies. Insert a small funnel in the open end of the chamber and place the chamber upright on the capped end. Tap 20–30 fruit flies into the choice chamber using the funnel.

Step 2 After transfer, quickly cap the other end of the chamber.

Step 3 Begin your study of the choice of flies by placing a few (5–10) drops of distilled water on two cotton balls, and adhere one moist cotton ball to each end of the chamber. (Do not add too much of any chemical to the cotton; too much liquid will drip down into the chamber and affect the experiment by sticking flies to the bottle.) What is the importance of using distilled water at both ends of the chamber?

Step 4 Lay the chamber down on a white surface or on white paper.

Step 5 Give the flies at least 5 minutes of undisturbed time, and then count (or closely approximate) the number of flies at each end of the chamber. Create a table to record the number of flies you find at each end (A and B) of the chamber.

Step 6 List all of the substances that you will be testing, and predict what you think the flies will prefer based on your knowledge of fruit flies.

Step 7 Begin to test each substance you are including in your investigation. Place a few drops of one substance on a cotton ball. Remove cap A, place the cotton ball in the cap, and replace the cap on the chamber. Place a cotton ball with distilled water on the other end. How might you determine which of the substances stimulate a negative chemotaxis and which stimulate a positive chemotaxis?

Step 8 Lay the chamber down on a light colored surface (or on white paper) and observe the flies.

Step 9 Give the flies at least 5 minutes of undisturbed time, and then count the number of flies at each end of the chamber.

Step 10 Change the caps, and give the fruit flies another substance.

Step 11 Gather data for at least four different substances. Which substances do fruit flies prefer? Which do they avoid?

Step 12 Quantify the results and express them graphically. Complete a chi-square analysis of your results. Using data from the entire class, construct a preference table. Were your hypotheses about the preferences of fruit flies supported or not? Did the flies demonstrate a chemotaxis in relation to any of the substances you chose? Can you think of any reasons for their preferences?



■ Designing and Conducting Your Investigation

Now that you have discovered the preferences for individual substances, design an experiment using the choice chamber to compare the preferences of fruit flies to all test substances or the chemotactic responses of your flies. Create a table that includes the results comparing all of the substances you tested.

The following are questions that you could investigate; however, as you worked through the beginning of this lab, you should have developed your own question and an investigation to answer that question:

- Are all substances equally attractive or repellant to the fruit flies?
- Which substances do fruit flies prefer the most?
- Which substances do fruit flies prefer the least?
- Do preferred substances have any characteristic in common?
- What other factors might affect whether or not the fruit flies moved from one part of your choice chamber to another?
- Do you think that it is the fruit itself that attracts the flies? Should they be called *fruit flies* or something else?
- Some experiments could be designed using fruit fly larvae. Do larvae respond the same way that adults respond? Are there other factors in the environment that affect the choice?
- What factors must be controlled in an experiment about environmental variables and behavior?
- What is the difference among phototaxis, chemotaxis, and geotaxis? Do fruit flies demonstrate all of them?
- Does a phototactic response override a chemotactic response?
- Does the age of the fruit fly change its geotactic response?
- Are there other organisms that respond the same as fruit flies? Are there other organisms that respond differently from fruit flies?

■ Analyzing Results

Look for patterns in fly behavior based on the number and ratio of fruit flies on different ends of your choice chamber. How will you determine which of the substances stimulate the greatest negative chemotactic response and positive chemotactic response? Do you see any patterns about materials or forces to which fruit flies are attracted?

Develop a method for sharing your results and conclusions to classmates — and then share them!

■ Evaluating Results

1. Is there anything that was shared by all of the environmental factors to which the flies were attracted?
2. Is there anything that was shared by all of the environmental factors to which the flies were repelled?
3. How do you explain the behavior of fruit flies in someone's kitchen or in nature based on the information you collected? Do your data explain all fruit fly movements? Explain your answers.

■ Where Can You Go from Here?

One possible extension for this investigation is to identify another organism that behaves similarly to the fruit fly and one that you expect would behave differently. For example, you could substitute ladybugs, houseflies, or mealworms for fruit flies and construct choice chambers using other substances that you think might be attractive to these organisms.