GENETICS AND ENVIRONMENTAL INFLUENCES ON PHYSICAL TRAITS

By Katherine M. Hartman, M.Ed., and Erin S. Kelleher, Ph.D.

OVERVIEW

Students will test two alternative hypotheses to explain observable differences fruit fly eye color. 1) Eye color differences are caused by environmental differences in diet. 2) Eye color differences are caused by genetic differences. To this end, the student will allow the offspring of fruit flies (*Drosophila melanogaster*) with different eye colors to develop on different colors of food, and observe the eye color at the adult stage.

OBJECTIVES AND STANDARDS

Conceptual Learning

- Individuals in populations vary in observable characteristics.
- Variation in observable traits is determined by an individual's genetic material and their environment.
- Genetic material is passed from one generation to the next by chromosomes in the nucleus.
- Chromosomes contain individual genes which influence observable traits.

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

7.11: The student knows that populations and species demonstrate variation and inherit many of their unique traits through gradual processes over many generations. The student is expected to (A) examine organisms or their structures such as insects or leaves and use dichotomous keys for identification.

7.14: Students know that reproduction is a characteristic of living organisms and that the instructions for traits are governed in the genetic material. The student can (A) Define heredity as the passage of genetic instructions from one generation to the next generation; and (C) Recognize that inherited traits of individuals are governed in the genetic material found in the genes within chromosomes in the nucleus.

Funded by NSF Grant 1457800 to Erin S. Kelleher

NEXT GENERATION SCIENCE STANDARDS

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-LS3-2: Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

TIME

2 class periods (15 minutes setup, 45 minutes for activity); allow 2–3 weeks between Parts 1 and 2.

MATERIALS

Items which can be purchased at Carolina Biological Supply Company (CBS) are marked with their specific product names and stock numbers, beginning with "CBS#" (https://www.carolina.com/).

- Drosophila media (CBS# 173210).
- Drosophila vials with enclosures (CBS# 173076, 2 per student/group)
- FlyNap® Anesthetic Kit (CBS# 173010). Each kit contains 12 wands and a 10 mL vial of FlyNap®, which provides 100 doses. Flies remain "napping" for 50 minutes to several hours without being killed or sterilized.
- Vials containing *Drosophila melanogaster* (fruit flies) having different eye colors.
    - CBS# 172100 (standard red)
    - CBS# 172220 (white, Chromosome 1 mutation)
    - CBS# 172225 (white-apricot, Chromosome 1 mutation)
    - CBS# 172360 (red-brown, Chromosome 2 mutation)
- Vials of *Drosophila melanogaster* having the same eye color (select from list above)
- Fine markers or pens
- Food coloring
- Microscopes
- Paint brushes
- Photocopies of each student page, 1 per student or student team or group

Option: Make sure you maintain vials of live fruit flies for students to use for their experiments. However, if you also wish for students to examine dead flies, place vials of flies in a freezer for 20 minutes. Be certain to freeze the vials upside down (cotton-side down), so that the flies fall drop to the cotton as they die and do not get stuck in food.

SETUP

Order fruit flies and appropriate supplies from CBS as indicated above and according to classroom size. For more information about Flynap® kits and the anesthetic process, view the following CBS videos.

"Flynap" (https://www.youtube.com/watch?v=DkiCFkB9cSo), "Observing Phenotypes and Crossing "*Drosophila melanogaster*" (https://www.youtube.com/watch?v=DkiCFkB9cSo)

Funded by NSF Grant 1457800 to Erin S. Kelleher © University of Houston.
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).

Sort fruit flies by eye color. Place fruit flies having the same eye color in vials; and fruit flies having different eye colors in different vials.

Set the power on all microscopes to 20X.

Photocopy or print student sheets for each class period (1 set per student or student team).

For Class Period 1: Load and open the activity's classroom PowerPoint® slide set. Anesthetize the fruit flies with different eye colors using FlyNap®. To do this, dip the wand into the FlyNap®. Turn the culture vial of flies upside down, then slide wand in between the cotton and side of the vial. Continue to hold the vial upside down while the flies fall asleep and drop onto the cotton (see demonstration video URLs listed on page 2, above). This may be done just prior to "Part 1b. Activity."

For Class Period 2: If you prefer to look at the offspring sooner than two weeks, you can set up the control and test vials in advance of the class. Simply perform steps 11–15 two weeks before you proceed to Part 2.

PROCEDURE

Class Period 1. Discussion and Observing Adult Fruit Flies

1. Project *Slide 2* containing images of flamingos and people with different traits on the front board. Ask students to make observations of the images. Guide them with information about the organisms. Ask, *What are some of the observable traits? What traits do all the members of the populations have in common? Different? Where traits are inherited vs. influenced from the environment?* Solicit hypotheses from the students, then discuss each proposed factor together as a group.

2. Lead students in a discussion of how different factors: environmental (diet, UV light, temperature; students may have other ideas) developmental (age) and genetics all contribute to variation in observable characteristics as you work through the slides.



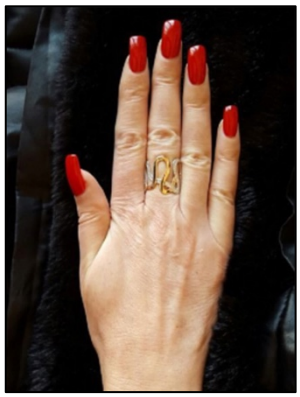
Diet — Explain to your students that diet is known to influence pigmentation. For example, flamingos and tuna eat a diet that is rich in pigmented foods, which causes their feathers and flesh to be pink.

UV Light — Discuss with your students how UV light alters traits, for example by darkening skin color and lightening hair color.

Age — Discuss with your students how aging affects physical traits. What sorts of traits have they noticed change with age in their families? Height, weight, freckles, hair turning gray, and eye color are all examples of traits that can change with age.

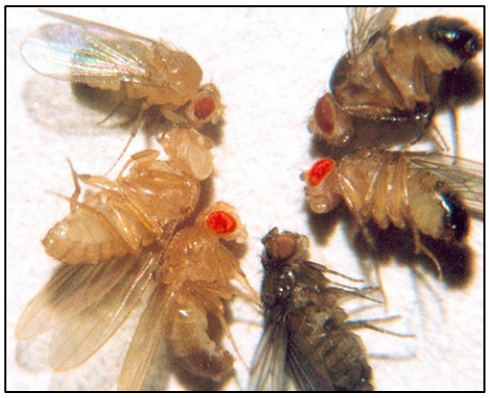
Funded by NSF Grant 1457800 to Erin S. Kelleher © University of Houston.
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).


Temperature — Describe to your students how temperature can affect traits. For example, Siamese cats raised in cooler climates (left) exhibit darker pigmentation than those raised in warmer climates (right).

Genetics — Explain to students that variation in genes are known to influence many observable characteristics in humans, such as hairline (straight or peaked), eye color, and the number of fingers and toes. Ask if they've noticed unusual traits that run in their families.

3. Project the image of fruit flies with different traits on the front board. Lead students in a discussion by asking questions like, *What are some of the observable traits? What traits do all the members of the population have in common? Are different? Which traits are inherited vs. influenced from the environment*?



Funded by NSF Grant 1457800 to Erin S. Kelleher

4. If you already have not done so, anesthetize the fruit flies with FlyNap® (see SETUP).

5. Place vials of sleeping flies by each microscope station. First have students look at and compare different flies at 20X. Keep in mind that students may want to increase the magnification to look at finer structures on the flies.

6. Ask students to look at the flies, determine how they are different, and sort them into groups according to differences. Have students complete the student worksheet for Part 1. Demonstrate and instruct them to use the paint brushes to manipulate the flies.

7. Survey the students about the physical traits they observed that varied among the flies. They are likely to see different eye colors. They also may also notice differences between males and females (females are larger and have a more pointed abdomen with lighter pigmentation on it).

8. Lead the students in a discussion about why the flies have different eye colors. Guide the discussion into testable alternative hypotheses ("genes," "temperature," "UV light," etc.).

9. Explain to students they will be determining whether genetics or dietary factors affect eye color in fruit flies. Also tell them that they will rear flies on different colors of food to determine whether and how their eye colors might be affected.

10. Tell students to make and record their predictions of the experiment outcomes on their worksheets. Ask, *What outcomes do you expect if diet is responsible for differences in eye color? What outcome do you expect if genetics are responsible for differences in eye color? What outcome do you expect if both factors contribute?*

11. Have students select one eye color they would like to test. Ensure that they have at least 20 live flies with that eye color and about equal numbers of males and females.

12. Give each student group two vials of fly media. Have students label their first vial as "Group #_____ Control" and the second vial as "Group #_____ Experiment."

13. Prompt students add 2 drops of food coloring into the vial labeled "Experiment."

14. Have students divide the flies they have selected into two groups of 10. Ensure there are similar numbers of both male and female flies. Students will then place the flies into the vials and close the vials with a cotton ball. Vials will then be placed in a classroom location for observation.

15. Keep adult flies in the appropriate treatment vials for 5 days, then discard them (you can anesthetize the flies with Flynap®, then dump them in a cup of soapy water, or alternatively, you can tap the parents directly into soapy water.) *You must retain the original vial, since this is where your offspring are developing.* In 2 weeks students will have plenty of F1 offspring from their cross.

Funded by NSF Grant 1457800 to Erin S. Kelleher
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).

Class Period 2. Examining Offspring

2–3 weeks after you start the experimental vials (1–2 weeks after discarding parent flies)

1. You will have lots of offspring to examine. Anesthetize or freeze-kill the flies and place in vials for each student (see SETUP).

2. Ask each student to identify eye colors of the flies in their vials **separately**. They also need to sort count the number of flies by eye color and record the data.

3. Put all the students data together, recording the student's name, parental eye color, offspring eye color, and treatment group (Control or Experiment).

4. Discuss with your students what determines offspring eye color. For example, is it the parents' eye color, or an environmental effect?

5. Reinforce that traits that are transmitted from parent to offspring are determined by genes, which are located on chromosomes inside the nucleus of cells.

Class Period 2. Extensions

Have students brainstorm other conditions they can manipulate, such as the following.

- Light — Place flies near windows or in a cabinet.
- Temperature — Place some flies near a heater, others not.
- Age — Allow some flies to mature longer than others.

IMAGE SOURCES

Page 1. Photo of a single *Drosophila melanogaster* fruit fly © Roblan. Licensed for use.

Page 4. Photo of Afro North-American female with preaxial polydactyly courtesy of Cplbeaudoin, Wikipedia, CC-SA 3.0. https://commons.wikimedia.org/wiki/File:Wanitetlefthand.jpg

Page 4. Photo of fruit flies is in the Public domain. https://commons.wikimedia.org/wiki/File:EyeColors.jpg

Unless noted, the remaining images in this document are courtesy of Pixabay, CC-BY 2.0. https://pixabay.com/

Funded by NSF Grant 1457800 to Erin S. Kelleher © University of Houston.
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).

OBSERVING ADULT FRUIT FLIES

Name _____ Date _____

Your teacher will provide you with sleeping fruit flies to observe, as well as other materials. Use the paint brushes to gently push the flies around. What physical characteristics are the same among all the flies? What physical characteristics are different? Answer the questions below. If you need more room, use the back of this sheet.

1. Separate your flies into different groups that all share the same physical characteristics. Describe the physical characteristics of each group you observe.

2. Isolate a group of at least 20 flies with the **same** eye color. What eye color did you select?

3. You may dispose of the other flies that you did not select in a container of soapy water provided by your teacher.

4. Obtain two vials of the fly food from your teacher. Label the first vial "Control" and the second vial "Experimental."

5. Add 2 drops of food coloring into your vial labeled "Experimental."

6. Divide your flies that have the eye color you selected into 2 groups. Ensure there are similar numbers of both male and female flies. Place them into the vials and close the vials with a cotton ball. Place the vials in the location your teacher has specified.

7. Keep adult flies in the appropriate treatment vials for 5 days, then discard them when instructed to do so by your teacher.

    a. What outcomes do you expect if diet is responsible for differences in eye color?

    _____

    b. What outcome do you expect if genetics are responsible for differences in eye color?

    _____

    c. What outcome do they expect if both factors contribute?

    _____

Funded by NSF Grant 1457800 to Erin S. Kelleher © University of Houston.
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).

EXAMINING OFFSPRING

Name _____ Date _____

1. Your teacher has placed sleeping offspring from your Control vial at the microscope station. Make observations and complete the data table below.

CONTROL VIAL

Parent Eye Color	Number of Offspring	Offspring Eye Color

2. Your teacher has placed sleeping offspring from your Experimental vial at the microscope station. Make observations and complete the data table below.

EXPERIMENTAL VIAL

Parent Eye Color	Number of Offspring	Offspring Eye Color

3. Answer the following questions. If you need more room, use the back of this sheet.

   a. How did the eye colors from your two groups compare? Were they the same or different?

   _____

   b. Was the eye color of your offspring the same as that of your parents? What caused this?

   _____

   c. In your experiment, was fruit fly eye color determined by genetics or by their diet?

   _____

   d. Did the data you collected support your hypothesis? Why or why not?

   _____

Funded by NSF Grant 1457800 to Erin S. Kelleher © University of Houston.
Dissemination of this activity provided by Baylor College of Medicine via its BioEd Online website (www.bioedonline.org).