# Life Cycles of *Drosophila*

## OVERVIEW

This unit is a series of inquiry lessons based around mating *Drosophila melanogaster* (fruit flies) to help students become comfortable with the science inquiry process and instruments as well as support the 7th grade Science standards of observing life cycles.

| AUTHOR | GRADE LEVEL | CONTENT AREA |
|---|---|---|
| Christine Sudzina Schut | 7 (Could be adapted to 6-12) | STEM |

## ESSENTIAL QUESTIONS

How do environmental factors affect the development of and propagation organisms?

What similarities and differences exist between the life cycles of *Drosophila* and other organisms?

What are the advantages of using stereoscopes to study *Drosophila* life cycles compared to other observation methods?

## TIME NEEDED

Time to gather the materials depends on your resources. I received all of my *Drosophila* vials, food and flies from my Kenan Fellowship mentor.

The preparatory lessons take approximately 3-4 days to learn to use the stereoscopes, create data tables, ID phenotypes and practice chill comas.

The life cycle of *Drosophila* is approximately 2 weeks, but we observed for 6 weeks to be able to see several generations and changes in *Drosophila* size due to environmental pressures.

1 lesson with Kenan mentor and *Drosophila* specialist.

1 wrap up and reflection lesson.

## NC STANDARDS

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

7.L.2 Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation and survival among offspring.


# Making **Connections**

Before the lesson, students brainstorm what they already know about *Drosophila melanogaster* and their life cycles. Students discuss how we use different instruments to make observations and discuss how they think the environment can impact an organism's development and life cycles.

# Background

This unit is a series of inquiry lessons to help students become comfortable with the science inquiry process and instruments as well as supporting the 7th grade Science standards of observing life cycles. In the introductory lessons, students become comfortable using stereoscopes and observing patterns of different or recurring phenotypes in *Drosophila*. The next lessons are to practice putting *Drosophila* in chill comas and flipping them into new containers. In these lessons, students work together to create their own data tables for our upcoming inquiry lab.

To start the inquiry lab, students will pick out mating pairs of *Drosophila* and observe the parents' phenotypes. After 3 days, students flip the parents into a different vial and begin to observe their first generation of offspring. Do NOT teach about the *Drosophila* life cycles ahead of time so students have to discover the eggs, larvae, pupae, and eclosion into adulthood on their own.  Students will observe how the phenotypes, particularly eye color and wings, change over time. The first generation of offspring need to be observed for a minimum of 2 weeks.

After students complete their observations, if possible, have a researcher come present to the class regarding how they use *Drosophila* as their model organism, as well as answer student questions. Finish this unit with students revisiting the essential questions asked at the beginning of the unit, now using data from their own observations to provide evidence for their answers. Complete the unit by having students draw a diagram of the life cycle of *Drosophila* and the timing of each phase. Students will end the unit with a reflection via Google form.

# Materials

**Preparatory Activity Materials:**

- Stereoscopes (I recommend 2 students assigned to one stereoscope.)
- Assortment of materials to put under the stereoscopes (Can be anything. I let students decide.)
- 16 different phenotypic combinations of *Drosophila*.
  - I was given dead *Drosophila* by my UNC mentors. There were 16 different combinations of phenotypes, including curly vs. straight wings, full vs. serrated wings, white, orange or red eyes, males vs. females, long hair or stubble, 3 chest hairs vs. lots of chest hair, etc.
  - If you are ordering *Drosophila*, freeze some of them for students to be able to observe before you start cross-breeding them.
- Paint brushes and/or tweezers to move the dead *Drosophila* without damaging them.
- Petri dishes to put dead *Drosophila* in to observe them under the stereoscopes
- White board for students brainstorming
- Paper/pencils or computers for students to create their own data tables.
- Phenotypic ID Chart (to be used after students have observed phenotypic patterns on their own.)
- Bucket of ice (for chill coma)
- Living *Drosophila* (We used random castoffs from the lab. This is for learning how to do a chill coma and flip flies into new containers.)

**Additional Materials Needed for the Main Activity:**

- Mating pairs of *Drosophila*. We used 18-20 virginal females and 4-6 males. Virgin females tend to be more willing to mate with non-virgin males than with virgin males, who have yet to practice songs or other courtship behaviors. We had 4 different combinations of phenotypes to breed so that students could observe different traits.
- At least 3 empty vials with food for each set of breeding *Drosophila* pairs.
- Labeling tape
- Thin-tipped permanent markers to write on tape

- Students' data tables

**Additional Materials Needed for the Wrap-Up and Reflection:**

- If possible, a researcher experimenting with *Drosophila*. One of my mentors came and presented it to my class. I do not have his presentation to share.
- Student reflection survey (You can create this using a Google form).

# The **Unit**

### Lesson 1; Part 1: Brainstorming Background Knowledge

- Start the lesson with students brainstorming what they already know about *Drosophila* and their life cycles, how scientists use different instruments in science to make observations, and how students think the environment can impact an organism's development and life cycles.
- Use "Think-Pair-Share" with students brainstorming on their own for 3 minutes and writing down their own ideas, then partnering and sharing for 5 minutes. Finally, have students take turns leading a class discussion and recording their ideas on the board.

### Lesson 1; Part 2: Introducing Stereoscopes

- Number all of the stereoscopes and assign groups of 2 students per stereoscope. This will be their personal stereoscope for the remainder of the unit.
- Give a brief introduction on how to safely carry and care for the stereoscope. Do not explain the fine and coarse knobs nor the lower and upper lights. Allow for students to discover on their own how the knobs and lights can be used to better observe objects.
- Allow students to put any objects (within reason) under the stereoscopes and figure out how to get them in focus and try the different lighting settings.
- Today is a "play/discovery" day. Students do not have to record their observations or findings.

### Lesson 2: Using Stereoscopes

- Open the lesson with students sharing what they learned/realized about using the stereoscopes and how the different lights/settings can help observe different objects.
- Task students with observing 5 different objects of their choice under the stereoscopes and writing down their observations.
    - An extension may include having students practice using their chromebooks/iPads/phones to take a picture of their objects under the stereoscopes.
- After 25 minutes, have students set up their favorite objects underneath their stereoscopes.
- In small groups, have students share with the class what the object looks like; how they used their stereoscope settings to best observe the object; what they found surprising and why that was their favorite object. (Favorite objects often are computer screens, printed pictures and their own skin.)
- End the class with a discussion about what settings worked best and what objects were most interesting/surprising.

### Lesson 3: Observing *Drosophila* Phenotypes

- Open the lesson with students sharing what they know about creating data tables. What is important? How do we choose headings, units, dates, etc.?
- Continue the class discussion to have students share what they already know about *Drosophila* and their features.
- Task students with creating a data table to record their observations of 16 different sets of dead *Drosophila* using their stereoscopes.
    - Before this lesson, I separated the 16 different phenotypic combinations of *Drosophila* that I was given by my UNC mentors into petri dishes and labeled them A-Q.
- Have students work in pairs to compare and contrast the different fruit flies and see if they can observe patterns of different or recurring phenotypes.

- Students may not get to all of the 16 samples, but they should have enough to be able to observe the different phenotypes of eye color, wing length and shape, male and female body types and hair length and amount.

- As a class, discuss what features/patterns they noticed. Then present the slides on the different phenotypes/features present in the fruit flies and which phenotypes are present in the samples.

### Lesson 4: Observing Living *Drosophila* and Practicing a Chill Coma and Flipping

- **Before class**, make sure to get a bucket of ice ready to perform the chill coma.
- Open the lesson by reviewing what phenotypes students observed the day before.
- Have students take out their stereoscopes again, but instead of observing dead *Drosophila*, each pair will receive a vial of living *Drosophila*. Have students observe and determine the phenotypes they see and if they are looking at vials of males or females. Have groups swap vials and discuss.
- Gather the class into one group and ask students to predict what they think would happen to the *Drosophila* if they were put into cooler temperatures.
- Demonstrate how to perform a chill coma by placing the vials of the practice *Drosophila* into the ice bucket for 2 minutes. Take the flies out and allow students to watch the flies slowly wake back up. Repeat the chill coma process and then show students how to “flip their flies” into a new vial. (Here is a video about how to flip your *Drosophila*.)
- After demonstrating these skills, introduce the inquiry project that students will start the next day, where they will combine virginal females and male *Drosophila* of their choice to mate and then observe the offsprings’ life cycle.
- Allow groups of students to bring their vials of living *Drosophila* up and perform a chill coma and practice flipping the flies.

- Pairs of students who are not actively performing the chill coma and flipping the flies will work on creating a data table for their mating *Drosophila*.
- Continue the lesson with a full class discussion, asking students to share headings that they think are important for their data tables and what information should be observed and recorded.
  - Allow students to brainstorm together. Some may have the idea of counting eggs or measuring the size which will not be possible but allow them to figure this out on their own during the experiment.
- Before leaving class, all students need to create their own data table to begin recording their observations the following day.

### Lesson 5: Mating the *Drosophila* (Day 0 of the *Drosophila* life cycle)

- Open the lesson with students sharing how to identify male and female *Drosophila*.
- Allow pairs of students to come to the front of the room and choose different vials to observe.
  - The vials will contain only male or only virginal female *Drosophila* with particular phenotypes (i.e. red eyes, white eyes, curly, straight or serrated wings).
- The student pairs will then pick the males and females that they want to mate and write down their original observations of the parents.
- Students will get a new empty vial with new food at the bottom and label it with tape and a sharpie marker. Students will include their names and the date on the new vial.
- Students will then perform a chill coma on their males and females and flip them together into the new labeled vial.
  - Make sure to place the vial on its side so that the flies don't get stuck in their food.
- As the *Drosophila* wake up, have the students observe their behaviors and how they are interacting with each other. If possible, have students take pictures of their parents.

- **Between today and Day 3**, depending on time, you can take the first 5-10 minutes of class for students to observe their flies and food with their naked-eyes and their stereoscopes.
    - Suggest that students look at the top layer of the food; this is where you will be able to see larvae when they hatch from the eggs that will be buried in the food. The larvae look like grains of rice with little black dots that are their mouths. If possible, have students take pictures.

### Lesson 6: Flipping Mating Pairs (Day 3 of *Drosophila* life cycle)

- **Before class**, make sure to get a bucket of ice ready to perform the chill coma.
- Start the class with students observing their flies, food and possible larvae in their original breeding vial. On Day 3, it is time to flip the parents out of their original mated vial.
- Have students label a new vial with the date, their name and that they contain the original mated parents.
- Have students put their current vials in the ice bucket for around 30 seconds (enough to slow the parents down) and flip them into the new vial. The vial with the parents is now just a holding container and secondary for observations.
- Now that the parents are removed, have students observe their original vials under the stereoscopes. Ask them if they see any movement, new shapes or colors. Have them record their observations in their data tables.
- Have students share their observations and infer what they are seeing. It is important not to tell students what they are observing. Let them figure it out on their own.
    - At this point students should be able to see the larvae (rice grain sized) moving around the top layer of the food. The food may have darker spots where the larvae have churned it up.

### Observations Weeks 0-4 (length of experiment at teacher discretion)

- *Drosophila* take approximately 2 weeks to go from egg to adult, depending on temperature (warmer=faster). During this time period, I would recommend that students observe at least 2-3 times per week for the first 10 minutes of class. If possible, have students take pictures.
- Guide students to look at the phenotypes of the offspring. Are they the same or different from the parents?
  - To slow down the offspring, you can perform a quick chill coma or put them in the refrigerator to make it easier for students to observe them.
- After the *Drosophila* in your original vial have eclosed, you can flip them into another new vial and observe their offspring's life cycle. If you allow the 2nd generation to eclose in the original vial, they will be considerably smaller than the previous generation, due to lack of food. Students should easily be able to observe this and draw connections between their observations and the essential questions.
- When students are completely done with growing their *Drosophila*, the teacher will put all vials into the freezer overnight. This will kill all *Drosophila* and allow for students to make their final observations in great detail. Use the petri dishes to put the deceased *Drosophila* and the paint brushes and tweezers to move them around without damaging them.

# WRAP UP **AND** ACTION

### Lesson 1: Specialist Presentation (My mentor was Dr. Drew Davidson)

My mentor from the UNC Chapel-Hill Hige Lab came in to discuss the importance of *Drosophila* as a model organism, why we use them, and what his post-doctoral research is on. Additionally, students had the opportunity to share what they observed over the *Drosophila* life cycles and ask my mentor, Dr. Davidson, questions. Listed below is a small sample of the student questions:

- **Q**: What is a *Drosophila's* age in human years? **A**: 4 days=18 years; 8 days = 70 years

- **Q**: What do the *Drosophila* climb into the cotton at the top? **A**: Insects innately crawl against gravity/ to the top. Fitness and age of *Drosophila* can be measured by how quickly they climb to the top. Using this understanding to study Parkinsons.
- **Q**: What do we use *Drosophila* to learn about the human brain and memories? This is specific to Dr. Davidson's research and he explained in a detailed PowerPoint.
- **Q**: How do *Drosophila* know where to lay their eggs? **A**: Females taste with their forelimbs (they only taste sweet, not bitter) and can determine where there will be food for their offspring when they hatch.)
- **Q**: What are all of the small balls on the sides of the vial? **A**: Fly poop
- **Q**: How closely related are *Drosophila* to humans? **A**: We share 61% the same DNA. Humans have 46 chromosomes; 1 pair is sex chromosomes. *Drosophila* have 8 chromosomes: 1 pair is sex, 2 pairs are all the other traits and the 4th pair they still don't really know what they do.
- **Q**: Can *Drosophila* drown? **A**: Not really/not quickly. *Drosophila* breathe through their skin. The small hairs trap air that they slowly absorb so they can survive underwater for days.

### Lesson 2: Class Reflection, Life Cycle Diagram and Answering the Essential Questions

- To finish the unit, have a class discussion revisiting the essential questions:
  - How do environmental factors affect the development of and propagation organisms?
  - What similarities and differences exist between the life cycles of *Drosophila* and other organisms?
  - What are the advantages of using stereoscopes to study *Drosophila* life cycles compared to other observation methods?
- Give students think-time to go through their data table to find specific data/observations supporting their claims before starting the full-class discussion.
- Students will then use their data to create their own to construct their own diagram drawing the life cycle of *Drosophila* and including the time period when the different phases occur.
- Students finished the unit by completing a google form reflecting on what they learned.

# Extensions

- There are so many extensions that could be done with this unit and it could be adapted to other standards like genetics (7th Science standard 7.L.2 Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation and survival among offspring. HS Biology Standard Bio.3.2 Understand how the environment, and/or the interaction of alleles, influences the expression of genetic traits.) Here is a link to the Berg Lab describing how to use *Drosophila* for Mendelian Genetics.
- Students could research nobel prizes that were won while using *Drosophila* as their model organism. References to these Nobel Prizes are in the *Drosophila* Workers Unite! manual.
- Students could observe mating dances/singing of the males to the females and tie that to HS NC Biology standard: Bio.2.1 Analyze the interdependence of living organisms within their environments. Here is a link to a lab observing courtship.
- Students could learn how *Drosophila* are used in optogenetics. Ted-Talk Re-engineering the brain.

# Resources

*Drosophila* Workers Unite! A laboratory manual for working with *Drosophila* By Michele Markstein

# About the Author

Christine Sudzina Schut has had a very diverse 20 year career in education. In 2002, her first teaching position was at an International School in Dresden, Germany as a middle and high school science teacher. After two years, she moved to Short Hills, New Jersey to teach middle school science in a public school for 2 years. Next, she moved to Rotterdam, The Netherlands, where she was middle and high school science teacher and Middle School Coordinator in an American International School; an English as Another Language teacher for 4-12 year olds in a Dutch public elementary school; and a thesis advisor, curriculum writer and college lecturer at 2 colleges in

Rotterdam and Dordrecht. After 9 years in the Netherlands, she moved to Chapel Hill, NC to teach multiple high school science subjects and be the Science Department Head at Graham High School in NC. After 4 years as GHS; she changed to East Chapel Hill High School to teach Biology and Astronomy for 3 years before moving to her current position at Culbreth Middle School where she is the AVID Site Coordinator and elective teacher for grades 6-8.

# About the Fellowship

As part of my Kenan Fellows Program for Teacher Leadership, I did research at University of North Carolina at Chapel Hill in the Department of Cell Biology and Physiology during the summer of 2023. My Fellowship, entitled "Memories and Fruit Flies," was in Dr. Toshihide Hige's lab, and I was mentored by Dr. Andrew Davidson and Dr. Daichi Yamada.

The Hige Lab's goal is to understand the mechanisms of animals' behavioral responses to sensory input depending on their past experience or current context. This is done at the levels of synaptic plasticity, neural circuit and behavior using the fruit fly, *Drosophila melanogaster*.

My Fellowship consisted of learning about their research, and then conducting three experiments of my own using different modified fruit flies. In the first experiment, we mated 3 pairs of fruit flies and then identified different gene insertions and their chromosome numbers through the 2nd generation's phenotypes. In the second experiment, I modified male fruit flies and observed differences in mating times due to inhibited courtship behaviors. In the third experiment, we bred fruit flies with manipulated protein channels that responded to optogenetics, producing innate responses by shining a red light on pupae.

I had so much fun being back in a research lab! I learned new lab techniques, like a "Chill Coma." To be honest, I would not have attempted nor created the lessons that my 7th grade students did if I had not had the opportunity to do it myself in the lab with Drew patiently guiding me along the way. Outside of my experiments, Dr. Drew Davidson taught me how to flip my flies, identify the different phenotypes and combine mating pairs as well as the life cycle and care of *Drosophila*. Being back in the lab reinvigorated me to get back into my students doing science and not just learning about it or following a scripted lab.

I could not have taught this unit without the support, friendship and mentorship of Dr. Davidson. He supplied me with 9 different phenotypic combinations of flies for students to observe. Then Dr.

Davidson gave me live *Drosophila* for students to observe and attempt chill comas and flipping with. He also captured, sorted and supplied several different phenotypic male and virginal female *Drosophila* for my students to observe and use for their mating pairs. Drew supplied food and vials for our generations of flies. Most importantly, Drew gave me the inspiration, energy and confidence to create a new unit for my 7th grade AVID students. My current 6th graders are already excited for next year when they will be able to breed their own *Drosophila*.

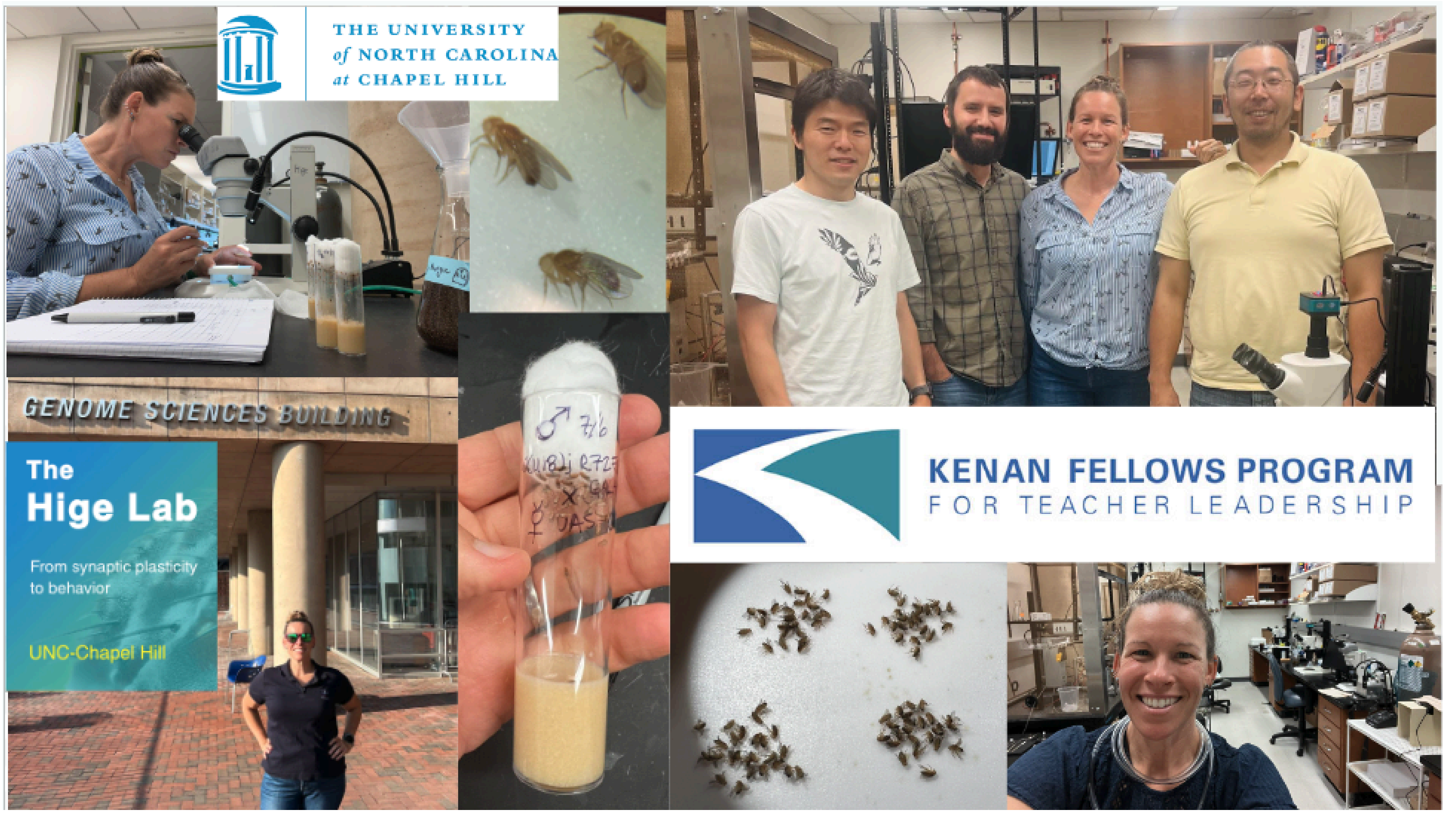
One student said in their reflection, “I liked doing something that felt like a real research study, and that it was something I would not normally be able to do.” This statement made me proud that the student feels this way and inspires me to provide all of my students with more opportunities to feel like they are doing “real research” in the future.

# Student Pages

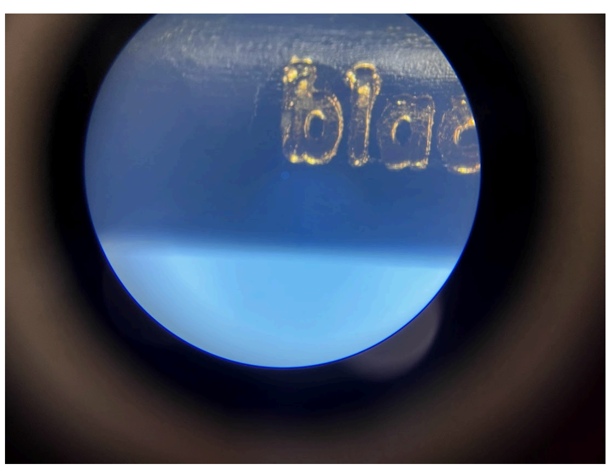
Students created their own data tables. I did not provide any materials so that students wouldn’t be influenced when creating their own materials.

# Appendix

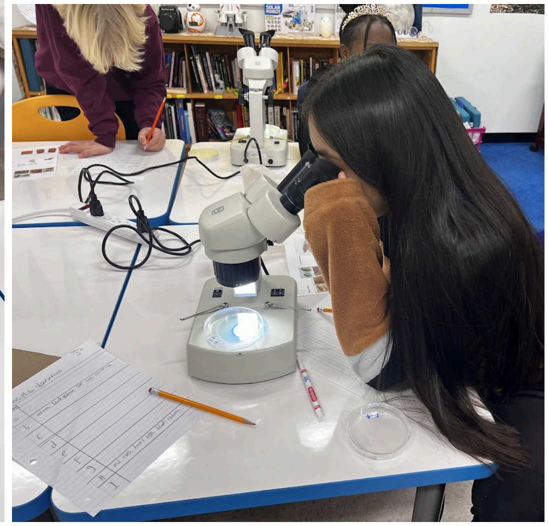
Here are a few pictures that show my Kenan Fellowship the parts of this unit:




Students practicing with the stereoscopes. Student picture of a colored pencil:



Different Phenotypic Combinations and Students Observing them in Petri dishes.

Performing a “chill coma” and learning how to flip flies:

Dr. Davidson with the collected males and virgin females for mating.

Day 0 Set Up and initial observation


Helping students flip their flies on Day 3:

Students observing their Drosophila larvae:

Comparing parents and larvae.


Just before eclosing begins:



Smaller *Drosophila* due to environmental conditions:


Dr. Davidson presenting to my students: