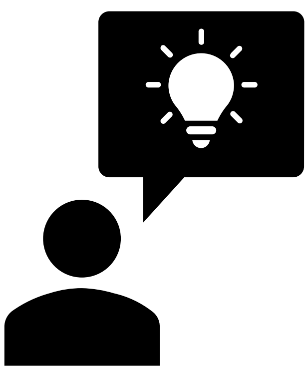
How can we use open space biology data to learn about the scientific method?

Background

The **scientific method** classically refers to a systematic and cyclic method of asking questions, gathering evidence, examining a claim through experimentation, and communicating those results. It is taught throughout different academic levels of science with varying degrees of specificity, such as a five-step process in elementary school or with emphasis on the iterative process during high school. The scientific method allows students to engage with the content they are learning and to apply concepts in an explorative and meaningful manner.

One method of enumerating the scientific method is as follows:



1. **Observe** the world around you
2. **Ask a question** about a phenomenon, detail, or occurrence
3. Do **background research** to gather a basic understanding
4. Construct a **hypothesis** (i.e., make a claim about your question in Step 2.)
5. Design and conduct an **experiment**
6. **Analyze** data from the experiment
7. Draw **conclusions**
8. **Communicate** findings

Although this description is enumerated, it is valuable to recognize that the scientific method is a cyclic and iterative process of discovery and re-discovery, and that is apparent by the availability of these datasets and the multitude of hypotheses that can be drawn from each one.

This activity presents an entry-level exploration of using the Open Science Data Repository datasets to practice aspects of the scientific method. Several worksheets and curricular units produced by teacher interns are available on this website that provide resources for a more comprehensive or a more advanced application of the scientific method.

Objectives

1) Review metadata of Open Science Data Repository datasets in order to recognize breadth and depth of studies with *Drosophila melanogaster*.
2) Differentiate between scientific (testable) and non-scientific questions.
3) Propose ideas for a scientific experiment using spaceflight data.

Datasets

The dataset used in this example is **OSD-347: *Heart Flies - effect of microgravity on heart function in Drosophila*** available from the Open Science Data Repository at https://osdr.nasa.gov/bio/repo/data/studies/OSD-347.

Introductory Activity: Asking Questions

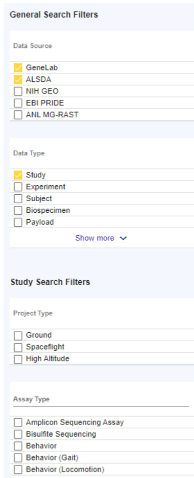
1) Keep a daily log of any open-ended questions that come to mind. *(Teachers may decide the duration of this log and the target number of questions. This is meant to be a very broad activity to help students become aware of questions that CAN be asked. Not all questions that come to mind will be scientific, and not all will be testable. This link to the "I Wonder Journal Challenge" available on the Society for Science webpage is an excellent example of how to do this activity: https://www.societyforscience.org/research-at-home/i-wonder/journal-challenge/.)*

Dataset Activity

1) **Navigate to the dataset:** https://osdr.nasa.gov/bio/repo/data/studies/OSD-347 (click on the link or use the QR code in the previous section)

2) Review the metadata of this study by reading through the sections, especially the **Description, Factors, Organisms, and Protocols** for the purposes of this activity. *(Teachers may emphasize different sections depending on what points they want to illustrate or personal preferences.)*

3) Using the information reviewed in Step 2, try to use the data repository to search for a similar study using the **General Search Filters** in the left panel. (Screenshot shown below, left.) *(By using filters for "spaceflight" studies and "fruit fly", a student might see the list shown in the screenshot below, right. Students can justify why they think the study is similar to OSD-347, and answers will vary. Answers can include type of organism, type of tissue in the organism, factors studied, etc.)*



Guiding Questions

These guiding questions can be answered in a discussion style, or teachers may opt to have students work in groups to create a poster that addresses each of the questions that will then be presented to the class.

1) **What model organism was studied in OSD-347? Does the study mention the strain of the organism? If so, what was it?**
   (This information will generally be found either in the description or in the protocols sections of the dataset/study)

2) **Based on the metadata available, what do you think the researchers of the study wanted to learn? Brainstorm questions that could be asked using the data presented.**
   *(Answers will vary. Questions that could be broad or specific, such as 1) What happens to fruit flies in spaceflight? How is the contractility of heart tissue affected by spaceflight conditions? How does the type of food used for the fruit flies affect the study? Does hypergravity affect fruit flies in the same manner as microgravity? Teachers may consider having students work in groups to ask 20 questions about the study, then sort questions by whether they are testable, scientific questions or whether they can be re-worded to become such. Discuss whether the question is testable or not. For example, each of the questions previously listed are testable. An example of a non-scientific (non-testable) question would be: "Do the fruit flies like being in space?" because we do not have measures of fruit fly entertainment or enjoyment. Another question could be "Which mutant did the researchers use and why?" and teachers and students could discuss why this is or isn't a scientific question, with the criteria that a scientific question is **testable.)***

3) **What tissues were collected in each of the studies?**
   (This information will generally be found either in the description or in the protocols sections of the dataset/study)

4) **How are the tissues collected? How do you think that collection methods differ on Earth versus in space?**
   (Example responses may address that organisms can be freshly dissected on Earth rather than using retrieved frozen samples; dissections in space are possible, but face different fluid pooling behaviors and require specialized techniques in tissue isolation.)

5) **Propose ideas for an experiment that could be conducted on fruit flies in space.** *(Answers will vary. This question is not intended for a student to describe a thorough protocol, but rather to suggest general ideas (This also provides an entry for providing more in-depth information on this model organism (i.e., https://droso4schools.wordpress.com, https://flybase.org). For example: Researchers could compare various fly behaviors in space (or post-spaceflight) vs ground controls – i.e. time how long it takes for a fly to get from point a to b; or whether fruit flies are attracted to the same colors in space as on Earth, feeding or mating behaviors. Researchers could test various developmental parameters – ie whether larvae develop at the same rate in space as on Earth, effects on number of eggs or viability of embryos, moulting etc. Researchers could also use mutants to study the above behaviors or developmental parameters, and/or use molecular tools (ie gene or protein expression). The method for this discussion question can involve having small groups of students design a poster that is presented to the class.)*

6) **Extension**: Design an experiment (or a device) that could be used to test the idea described in Step 5. *(Answers will vary. Students could conduct initial experiments to test whether fruit flies have a color preference at all. Students might consider building a 3D clinostat in order to test the effects of random positioning on fruit fly behaviors or use cameras to record behaviors in habitats. Depending on resource availability and student interests, teachers can mentor (or find mentors) to enable students to conduct the experiment that they design.)*

Alternative Activity for Early Learners

Since using the dataset activity might not be suitable for early learning, here are a few suggestions for engaging students with the space biosciences.

Watch a video clip about plants in space, for instance clips from **Expedition 66 Crew Grows Chile Peppers on the International Space Station Time-lapse (short version)** (https://images.nasa.gov/details/Peppers%20Timelapse%20Salsa%20Music%20Rev%204)

1. Have students describe observations. What is happening to the plant? What do they notice about its growth? Do they look like how plants grow on Earth? (Answers will vary depending on the video clip selected by the teacher, but could include details about the orientation of the pepper fruits, leaf size and shape, etc. Teachers should consider other comments such as personal experiences with growing plants, interactions with farms, or stories they have heard from families growing up in agricultural settings.)

2. Ask students to consider what are some things that plants need. Then ask, what are special things that a scientist would need to plan for a plant to be in space? (Answers should guide students to consider basic things such as light, water, nutrients, then depending on students, the teacher can probe for details such as gas exchange, resistance to disease such as fungal infections, pollinators if relevant to some types of plants, etc.)

Watch video clips about the behavior of water in microgravity conditions, such as **Moving Water in Space - 8K Ultra HD** (https://images.nasa.gov/details/Moving_Water_in_Space-8K) and **Space Hygiene: Showering in Space** (https://www.youtube.com/watch?v=tDbbJWKKQu0)

3. Ask students to consider how would that affect taking care of a plant in space. (Students might notice that water cannot be poured in space the way that it is on Earth, and that water seems to clump up. More advanced students might mention that this would make it difficult for a plant to be watered in a normal way. Students might or might not be able to glean from the videos that the light cycles in space differ from the day/night cycle on Earth.)

NGSS Science Standards

Strands: HS-LS1-2; HS-LS1-3; HS-LS4-1

Practices: Developing and Using Models; Asking Questions and Defining Problems; Analyzing and Interpreting Data

Crosscutting Concepts: Interdependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World

Common Core Standards

CCSS.ELA-LITERACY.RST.6-8.10. By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.