|  |  |
| --- | --- |
| **Title** | Design of Experiment: Optimizing Diets for Drosophila |
| **Introduction** | This lesson will focus on the design of an experiment (DOE) which is an essential component of developing young scientists. Fruit flies and their diets have been selected specifically in order to use the developed diets to study macromolecules and to breed the flies for study of ecological relationships, population growth curves and genetics. Data can be collected during this lesson and then used in subsequent lessons about different objectives. |
| **Learning Outcomes** | Students will be able to…   * Design an experiment with a clear control and experimental groups. * Judge the efficacy of an experimental design and make suggestions for improvement. * Create data tables and graphs which collect and share desired information. |
| **Time Required and Location** | This lesson will require concentrated time to set up the experiment and then brief daily “check-ins” over the period of 4 weeks for data collection. Then following data collection, teachers will need 60 minutes to debrief the activity. On the front end, teachers will need 135 minutes (3 class period, 1.5 block periods) for students to design and set up their experiments. Then, data on insect growth and reproduction will be collected. Each collection point will take approximate 15 minutes, and a minimum of two collection times per week is recommended. Students will be able to collect sufficient data over 4 weeks, however the longer the populations are allowed to grow the more data you will have to develop growth curves. |
| **Materials Needed** | * *Drosophila melanogaster* (6 per vial, minimum 3 vials per group) * Vials (minimum 3 per group) * Aerated stoppers (can use cotton balls) – 1 per vial * Anesthetizing agent for Drosophila melanogaster: carbon dioxide, cooling, or ether. * “Fruit fly food” – food provided with fruit flies upon ordering or a banana would suffice! * Brewer’s yeast * Sugar source (glucose, sucrose, fructose, etc). * Protein source (whey protein, soy protein, nutritional yeast, etc).   **Technology Resources:** Prior to completing this lesson, students should practice working with fruit flies. Students can practicing identifying the sex and different features of fruit flies through working with the following website: http://www.biologycorner.com/fruitflygenetics/ |
| **Participant Prior Knowledge** | **Pre-Activities:** This lesson is designed to be completed at the beginning of the Biology I curriculum as students are learning about the scientific method and experimental design. It is expected that students are familiar with the steps of the scientific method and key vocabulary such as: hypothesis, control, experimental group, independent variable, dependent variable, analysis, conclusion. Additionally, students should be familiar with basic knowledge of the fruit fly, including where they usually grow, how to sex, and how to anesthetize/handle them.  As part of this activity will require fermentation of yeast to create the insect food diets, it is encouraged for classes to complete a fermentation lab activity prior to making their diets. This will allow students to understand how yeast is used to ferment different food products. A fermentation activity has been created by the author to precede this lesson. |
| **Activities** | 1. Hook – “What’s for lunch?” Provide students with a host of typical items that may be found in a student’s lunch (apple, sandwich, pizza, salad, apple sauce, etc). Vary the types of food and the degree of “healthiness”. Ask the students on their own to argue if the lunch is healthy or not. Inform students you will be looking for their argument not necessarily the “right answer”. This often provides students with some creativity in thinking about how they view their food. Once students have had a chance to write for 5-10 minutes (depending on time available), call on a few students to share with the class. [20 minutes] 2. Brainstorm: In their lab teams (ideally 3-4), have students answer the questions: what makes a balanced diet? How do you measure if someone has a healthy diet? Once teams have had time to discuss, share out as a group and write the components of a diet and how to measure a healthy diet clearly for students to see. There are no “wrong answers” in brainstorming, but provide students leading questions to guide them to vitamins carbohydrates, lipids, and proteins as essential diet nutrients, and growth (height, weight) and reproductive rates as measures of healthy diets. [20 minutes] 3. Show students the ingredients for their insect diets. At a minimum, students should be provided with a variety of products including yeast and a variety of carbohydrate and protein sources. Additionally, each group will have a banana or “fruit fly food” provided by the fruit fly vendor made available to them as their control food. Additionally inform their group they will be supplied with a set number of male and female fruit flies. It is recommended each group has a minimum of 6 per vial they are going to grow in – but they have the ability to select how many of each gender. As a class, discuss what is known about each of the supplies provided. [10 minutes] 4. Before being given any supplies, in groups students must design experimental groups and a control group for each of their vials. They should include in their instructions if they will use head to breakdown/mix their diets. Students should be aware of how many vials they will be able to receive and how many fruit flies they can expect. The instructor should decide how to handle the gender of the fruit flies disseminated. Population growth will be effected by the starting gender ratio of the group – so, that will need to be considered when doing data analysis and when analyzing the experimental design of each groups experiment [10 minutes]. 5. Once students have come up with their “recipes” with clear measurements for each substance, the lab groups should record in their lab notebooks their recipes as well as a short rationale as to how each of the diets were planned. Include after the summary for each a hypothesis as to which of the diets they think will be most effective and why [20 minutes].    1. Later in the curriculum, as students learn about the macromolecules, you can return to their diet recipes to do a macromolecule analysis using indicators, spectrophotometers, or other methods for analyzing the nutritional content for diets made. 6. Students will then proceed to formulation of their diets. In groups, they should accurately measure substances and then place in the bottom of their empty vials [30 minutes]. *Once vials have been created, if heat was used time should be allotted for the vials to cool as to not burn the fruit flies.* 7. When vials have been set, students should then brainstorm how they will measure the efficacy of each diet. They should create a data table that supports their method of collection (will they measure weight change, body length change, reproductive rates, all of the above) [20 minutes]. 8. Students should anesthetize their fruit flies and place them into the appropriate vials. If they are responsible for counting and separating gender, it should be done at this time. Once each vial is set, initial data for each vial should be collected according to their set parameters. [20 minutes]. 9. Now, students are responsible for collecting data as set by the class (ex: every other day for 4 weeks). Students should record quantitative as well as qualitative data in their lab notebooks. 10. After the experiment is complete, students will analyze their collected data and conclude which of the diets seemed to be the most effective in creating healthy fruit fly communities. They should record their analysis and conclusions in their lab notebooks. 11. Each student group should prepare a summative poster that displays their DOE. This should include each component of a lesson plan. To save class time, this can be done as an at home assignment. 12. As a class we will evaluate the DOE of each of the groups and provide feedback. With each of the posters displayed around the class – students will individually move around the room with post it notes and provide positives and suggestions for improvement specifically focusing on the DOE. 13. Students will take their poster as a group and read through the feedback provided. |
| **Assessment** | Assessments for this assignment may vary. Some suggestions include:   * Oral reflections on their experimental design and how they could change it for improvement. * Written reflection on changes to their experimental design that would improve it. * Re-write the original lab report to reflect changes made to experimental design. * Provide students with a questionnaire regarding their design to reflect on their design and make suggestions for improvement. |
| **Critical Vocabulary** | Design of Experiment – DOE  Data  Analysis  Hypothesis  Controls  Control Group  Experimental Group  Method  Efficacy |
| **Extension Activities** | * Research assignments on healthy diets. Have students do a comparative analysis of the different diet requirements for different animals. Why would some organisms require more fat? More protein? More carbohydrates? * Provide students with experimental procedure scenarios. Have students identify the different parts of the experiment (control group, experimental group, conclusions drawn, etc) to familiarize themselves with how experiments are conducted. * Experimental design analysis. Allow students to read experimental procedures and have students decide the efficacy of the scientist’s design. Can they find errors in the way the experiments were set up? Instructor may vary the degree of difficulty of these situations based on the ability of the students. |
| **Modifications** | This experiment can easily be pared down if time does not permit. The teacher can prepare several mixed diets and name them and have students to design an experiment to see which mystery food is the most effective in growing their fruit fly colonies. Students should focus on experimental design – so focusing their design on only having one variable (the food type) and making the rest of their conditions identical. Additionally, the instructor may provide for students the method of data collection. Rather than having students come up with their collection processes on their own, the teacher may provide her students with a set form/guideline for students to collect specific information while they are doing their experiment. Regardless of the depth of the experiment, the objective should be clear that students are developing their own experimental design AND evaluating their process. Even if their experiment had flaws, the goal is for students to recognize their flaws and then be able to redesign a similar experiment more effectively. |
| **Supplemental Information** | Cohen, A.C. (2004). *Insect diets: science and technology*. Boca Raton, FL: CRC Press.    Practice Sexing Fruit Flies: <http://www.biologycorner.com/fruitflygenetics/sex.htm> |
| **Comments** | In attempt to link several units of the biology curriculum together, this lesson along with a few others were developed to use insects as a vehicle for deepening the understanding of the students of major concepts in biology and life science. Whether taught as an isolated lesson or in conjunction with the other related lesson, it is the goal of the author to connect biology students more deeply with the curriculum through continuous exploration through one living species. |
| **Author Info** | Sarah Kaneko is a biology and earth science teacher at CE Jordan High School in Durham, North Carolina. She began working at Jordan after completion of her M.A.T. at Duke University in the fall of 2007. She was drawn to the school because of the Freshman Academy program which activity works to support the transition and growth of ninth graders to high school through modes such as increased communication between each students core teachers, increased parent contact, academic skill building through a freshman seminar, and a structured study hall program to assist students with reviewing course material and working on homework assignments. She currently serves as team leader in this program.  Prior to pursuit of her MAT degree, Ms. Kaneko worked for two years at Durham Nativity School in Durham, North Carolina as a science and math teacher. Her interest at DNS began as a volunteer while she was a senior in college; she assisted with the after school homework and tutorial program as well as worked with the headmaster of the school with student recruitment. She began working at DNS following the completion of her B.S. in Biological Anthropology and Anatomy at Duke University. It was at DNS, her love of teaching became evident and returned to Duke to pursue a master’s degree in teaching and certification in teaching high school science.  Sarah Kaneko was supported during her Kenan Fellowship summer research by Dr. Allen Cohen, Director of Insect Diet and Rearing Research, LLC (IDRR). Prior to opening IDRR, Dr. Cohen worked for the USDA at Mississippi State University as a research entomologist and research leader for the ARS Biological Control and Mass Rearing Research Unit. In addition to his work in industry, Dr. Cohen also has an extensive history in teaching biology and entomology at the collegiate level and has been supporter and mentor for teachers in science education. This Kenan Fellowship was funded by NC BioTechnolgy Education Center (NC BTEC) |