Slugs and the Scientific Method

Objectives

In this lab you will:

- make observations of slug behavior.
- accurately record observations.
- understand the difference between an observation and an inference or an opinion.
- discuss findings with other class members.

Introduction

There are certain basic skills necessary for successfully carrying out any scientific investigation, be it the analysis of enzyme activity or the dissection of a worm. One of these skills is the ability to observe carefully and accurately. You will come across the word "observe" many times in your labs. Scientific observation is very different from observing a film or television show. First of all, observing is not limited to seeing. All of your senses may be used, and your senses may be extended with equipment such as microscopes. Therefore, odors, textures, tastes (but don't do it in lab), sounds, measurements of length, volume and mass are all considered observations and are the basis of data collection in lab. Ask yourself questions about the reasons for and the significance of what you observe. Record your observations carefully and accurately. Your conclusions will be based on your observations, so try not to fall into the trap of molding your observations to fit a preconceived notion of a "right answer."

Scientists must be aware of the distinction between true observations, inferences, and interpretations of observations and opinions. Carefully consider the following definitions when recording information as a part of an investigation.

- **Observations:** Data collected with any of the senses or tools such as thermometers, graduated cylinders, balances or rulers.
- **Inferences:** Conclusions or deductions based on observations; they may be very subtle and you may at first be unaware you are making them.
- **Opinions:** Everyone has them and everyone's opinion should be respected, but they should be left out of our data collection and analysis.

Materials

- Slug
- plastic container with lid to serve as "slug home"
- slug food such as lettuce or other leaves
- large petri dish to place slug into while making observations
- metric ruler
- hand lens
- dissecting microscope (optional)

Safety Precautions

- Good laboratory practice should be followed at all times during this laboratory.
- Treat the slug humanely. It is a living organism!
- Never consume laboratory specimens!

Procedure

1. Obtain a slug in a plastic container with a lid.
2. Make 12 observations of your slug - these may be anything about the slug's physical appearance or behavior - anything you can observe. Write these observations in the data chart on the next page.

3. When finished, exchange your data table with your partner and evaluate each others' observations; state whether each observation is really an observation, an inference, or an opinion.

Analysis

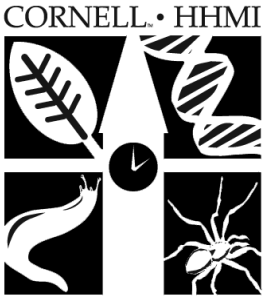
1. Take any 2 of your *observations* and intentionally make *inferences* about them. Express each of these inferences in a complete sentence.

2. Again using a complete sentence, state an *opinion* about slugs.

Slug Observation Data Table

Observer: _____ Record your observations below.	Evaluator: _____ Indicate the type of statement
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	

The Vermiculturist's Experiment



Objectives

In this part of the lab you will:

- examine an experiment for the integrity of its design.
- recognize when an experiment has a valid control.
- be able to explain the importance of replicates.
- analyze and interpret data.

Introduction

Several of the labs we will do this year will require you to design an experiment that will provide the answers to scientific questions. In designing your experiment, it is important that you understand the use of "controls."

A *control* is an established reference point. It allows you to make comparisons that generate valid information. The key to the use of a control is to be sure that, in any experiment, only one *variable* is changed relative to the control.

In this exercise you will be provided with data collected from a series of experiments designed to identify factors that optimize the production of earthworms. You will analyze the results of these experiments to learn the importance of *controls*, *variables*, and *replicates*.

Materials

- no special materials other than this lab write-up.

Procedures

A person involved with "vermiculture" (the raising of worms) is trying to determine the optimal (best) conditions for maximizing the reproductive rate of worms (the # of egg cases laid/24 hour time period). This person has identified the following variables that they would like to investigate:

- % moisture content of soil by weight
- whether the soil is covered or not
- the amount of food (cornmeal) spread on each square foot of soil.
- % sand in soil by weight
- % sand in soil by volume

Below is a chart of the conditions used for the past month with the averaged results (# of egg cases/24 hours).

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54

The vermiculturist decided to determine the effect of changing the variables. The following trial was tried for a period of one week and the results were once again averaged.

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
2	25%	10%	Yes	15 grams	92

Look closely at the two trials. In your opinion, what caused the large increase in the number of egg cases laid in a 24 hour period? On separate paper, explain how you arrived at this conclusion.

After looking at the set-up and the results of the two trials, the vermiculturist realized that it was impossible to be sure of what actually caused the huge increase in egg production because there are too many variables in this experiment. So, the tireless worm farmer

decided to try a number of additional trials in order to determine which variables had what effect. The results of these trials along with the data from the original trial are given below.

For each trial, using Trial #1 as the "control," write a conclusion stating what the vermiculturist could learn from his or her efforts.

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
3	20%	10%	No	10 grams	52

Record your conclusion for Trial #3 on your own paper. Explain how you arrived at this conclusion.

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
4	20%	15%	No	15 grams	64

Record your conclusion and reasoning for Trial #4.

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
5	25%	15%	No	10 grams	53

Record your conclusion for Trial #5 along with an explanation of how you came to this conclusion.

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
6	20%	15%	Yes	10 grams	82

Record your conclusion for Trial #6 along with an explanation of how you came to this conclusion.

The important thing about the set-up is that for each comparison, only one variable at a time is actually different. This makes it quite easy to determine the effect of that **specific** variable by always comparing it to the control. So far, we know that a good experiment must:

- have a control
- test only one variable at a time

In addition, a good experiment must have *replicates*, *be able to be repeated*, and have a *minimum number of assumptions*. Write a paragraph that uses information from the experiment to explain how the vermiculturist took care of the above three requirements. Record your answer on the same sheet of paper you used to explain how you arrived at your conclusions for each of the trials. **Be sure to use complete sentences for all of your answers.**

All Trial Data

Trial #	% Moisture in soil (weight)	% Sand in soil (Volume)	Soil Covered (Yes/No)	Amount of food given per square ft.	RESULTS # egg cases (in 24 hrs)
1	20%	15%	No	10 grams	54
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
2	25%	10%	Yes	15 grams	92
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
3	20%	10%	No	10 grams	52
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
4	20%	15%	No	15 grams	64
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
5	25%	15%	No	10 grams	53
Trial #	**% Moisture in soil (weight)**	**% Sand in soil (Volume)**	**Soil Covered (Yes/No)**	**Amount of food given per square ft.**	**RESULTS # egg cases (in 24 hrs)**
6	20%	15%	Yes	10 grams	82

Food Preferences of Slugs

Objectives

In this lab you will:

- design and carry out a biological experiment.
- make observations of slug feeding behavior.
- accurately record observations and organize data.
- draw conclusions and make deductions based on data.
- discuss findings with other class members.

Introduction

In this lab you will design an experiment, collect data, and analyze your results to test the feeding preferences of the common garden slug, *Arion subfuscus*.

Materials

- slug
- plastic container to serve as "slug home"
- slug food such as lettuce or other leaves
- graph grids transferred to transparency film
- hand lens
- metric ruler
- scissors
- dissecting microscope (optional)

Safety Precautions

- Good laboratory practice should be followed at all times during this laboratory.
- Treat the slug humanely. It is a living organism!
- Never consume laboratory specimens.
- Be careful when using scissors.

Procedure

In this lab, you will be asked to consider the feeding behavior of slugs and to also think of a question that you will then attempt to answer by measuring the quantity of food consumed by one or more slugs. While the example of the worms and the vermiculturist has nothing to do with the problem you will be facing in your lab this week, the process is similar. What are five characteristics of a good experiment? (Record your answer below.)

1.

2.

3.

4.

5.

Your experimental design should include each of the five characteristics you listed. You should also think about how you will collect your data and how you will analyze the data.

1. Formulate a question about the feeding behavior of slugs. For example, you might ask, "Do slugs have a color preference in the foods they eat?" Make sure your question is testable with the materials and the amount of time available. On a separate piece of paper, and using complete sentences, write down the following:

a. State the **hypothesis**.
b. Identify the **constants**.
c. Identify the **experimental variable(s)**.
d. How will the **data** be collected?
e. How many **replicates** will there be?
f. List three **assumptions**.
g. Check with your instructor to be sure your question and approach will be appropriate.

2. Decide what two food materials are necessary for your experiment and get them.

3. Cut a 20 mm x 20 mm square of graph grid.

4. Put the square on the leaf. Carefully cut around the square with scissors. Repeat this procedure until you have obtained two 20 mm x 20 mm squares of each of the two types of food you are testing. (If the leaf is too small or narrow to cut squares of this size, cut 20 mm x 10 mm rectangles or other shapes as directed by your instructor. Regardless of the size and shape of the pieces, it is important that all items of food have the same size and shape, and be added to the feeding container in the same total quantity.)

5. Examine the thickness of the squares. Since it is important that the volume of all the pieces be approximately the same, use a razor blade to cut any unusually thick squares down to a uniform size, or ask the instructor to do so.

6. Place the leaf squares on the bottom of the feeding container provided. Figure out a good and water-proof system for labeling your containers and squares.

7. Add 1 ml (about a quarter of a teaspoonful) of water to the container.

8. Deposit a slug in the container with the food and securely place the lid on the container. Be sure that the lid has numerous small air holes in it!

9. Label your container(s) and place them in the area of the room designated by your instructor.

10. Examine the container after 24 hours and count the number of small squares consumed for each food sample. Calculate the percentage of food consumed for each sample. To do this divide the number of squares consumed by the total number of squares of the food sample. (For example, if a slug ate 15 small squares of food A and 7 small squares of sample 2, then for sample A, 15/25 = 0.6, which is 60%. For sample 2, 7/25 = 0.28, or 28%.)

11. Record your results on the following page.

12. Clean out your slug container as directed by your teacher.

Data

Type of foods tested: Food A: _____

Food B: _____

Food A: _____		**Food B: _____**	
Amount (# of squares) of **Food A** *sample 1* eaten	(a) = _____ squares eaten	Amount (# of squares) of **Food B** *sample 1* eaten	(a) = _____ squares eaten
% of **Food A** *sample 1* eaten (% = number of squares eaten/ total squares available)	(b) = _____ % sample eaten	% of **Food B** *sample 2* eaten (% = number of squares eaten/ total squares available)	(b) = _____ % sample eaten
Amount (# of squares) of **Food A** *sample 2* eaten	(c) = _____ squares eaten	Amount (# of squares) of **Food B** *sample 2* eaten	(c) = _____ squares eaten
% of **Food A** *sample 2* eaten (% = number of squares eaten/ total squares available)	(d) = _____ % sample eaten	% of **Food B** *sample 2* eaten (% = number of squares eaten/ total squares available)	(d) = _____ % sample eaten
Average % eaten **Food A** note: (b+ d)/2 = average	_____ average % eaten	Average % eaten **Food B** note: (b+ d)/2 = average	_____ average % eaten

Calculations

Show your calculations for each step on your own paper.

Analysis

Using complete sentences, answer each of the following questions on **your own paper**.

1. Make a conclusion based on the results of your experiment. Write your conclusion in the form of a hypothesis.
2. Does the data support your hypothesis?
3. Design at least one other experiment to further test your hypothesis.
4. What were some possible sources of error in your original experiment?
5. How could you improve upon the design of your original experiment?

Food Preferences of Slugs:

The Next Chapter

or

Slugs II!!

Objectives

In this lab you will:

- formulate a hypothesis about slug feeding behavior.
- design and carry out a biological experiment to determine if your hypothesis is correct.
- make observations of slug feeding behavior.
- accurately record observations and organize data.
- draw conclusions and make deductions based on data.
- discuss findings with other class members.

Introduction

One of the most exciting things about science is that scientists never run out of questions! As a result of your last experiment with slugs, you may have discovered some of the foods that slugs seem to like, and some that they don't like. But is that the whole story? Of course not! Why do slugs "like" the foods they do and what experiments could you do to find out? If a slug liked (or disliked) a food when you tested it, does the slug always feel the same way about that food? Or do certain conditions make the slug "pickier"? What experiments could you do to answer these questions? You can probably think of many more questions about slug food preferences and you should have some good ideas about how to design experiments to answer these questions.

Your task for today's lab is to think of a specific question concerning the feeding behavior of slugs, write a hypothesis about slug feeding preference, and then design and carry out an experiment that attempts to test your hypothesis.

Materials

- slug
- plastic container to serve as slug home
- slug food such as lettuce or other leaves
- graph grids transferred to transparency film
- assorted other materials depending on design of experiment
- metric ruler
- scissors
- hand lens
- dissecting microscope (optional)

Safety Precautions

- Treat the slug humanely. It is a living organism!
- Never consume laboratory specimens.
- Be careful when using scissors

Procedure

1. Write a question about the feeding behavior of slugs. Express your question in the form of a hypothesis. Make sure your hypothesis is testable with the materials and amount of time available. Check with your teacher to be sure it is appropriate. Have your teacher initial here that your question is acceptable to test:

   _____

   initials/date

2. Determine what type(s) of plant material are necessary for your experiment, and obtain samples of each material needed.

3. Follow the same basic procedure as in the previous lab, modifying it as necessary to test your hypothesis. You may need to make special modifications depending on what your hypothesis states.

4. **Upon completion, of the experiment, write up your lab using the following format:**

I. Introduction

a. State your hypothesis.

II. Materials and Methods:

a. Briefly outline the procedure you followed and how you collected your data.

II. Results:

a. Present your data in a neat, organized and labeled table.

III. Discussion:

a. State a conclusion, if you were able to make one.

b. Describe any problems you encountered.

c. List any modifications you would make if you were to repeat this experiment.