Scientific Method

Adapted from Human Biology Lab Manual, Sylvia Mader, 9th Edition

Name: _____

Goal

The aim of this session is for students to outline the steps of the scientific method. You should also be capable of distinguishing between observations, hypotheses, conclusions and scientific theories. You should be able to design an experiment that can be repeated by others and reach a conclusion based on observation and experimentation.

Introduction

This lab will provide you with an opportunity to use the scientific method in the same manner that scientists do. Scientists often begin by making observations about the subject of interest. Today our subject is the pillbug, *Armadillidium vulgare*, a type of crustacean that lives on land.

Pillbugs have overlapping "armored" plates that make them look like armadillos. A pillbug can roll up into such a tight ball that its legs and head are no longer visible, earning it the nickname "roly-poly." They are commonly found in damp leaf litter, under rocks, and in basements or crawl spaces under houses. Pillbugs breathe by gills located
on the underside of their body. The gills must be kept slightly moist, and that is why they are usually found in damp places.

In winter, pillbugs are inactive, but when spring arrives, they become active and mate. Females have a pouch on the underside of their body where they can carry from 7 to 200 eggs. The eggs hatch several weeks after mating, and the young look like miniature adults. The young stay in the pouch another six weeks, and then they leave and begin to feed. They eat decaying plants and animals and some living plants. They can live up to three years.

Pillbugs molt (shed their exoskeleton) four to five times. They have three body parts:
head, thorax and abdomen. They have compound eyes and two pairs of antennae.

You are going to first become familiar with your subject and how it normally moves and then you will use your knowledge of the pillbug to hypothesize whether it will be attracted to, repelled by, or indifferent to various substances of your choice. After you have tested your hypothesis, you will conclude whether it is supported or not. Finally, your conclusions may lead to other hypotheses, and if time permits, you may go ahead and test those also.

Using the Scientific Method

Scientists use the scientific method to come to a conclusion about the natural world. A scientist begins a study by using preliminary observations and previous data to formulate a hypothesis. A hypothesis is a tentative explanation of observed phenomena. The hypothesis is then tested by conducting new experiments and/or making new observations. These experiments must be repeatable to be considered valid. An independent variable is what the scientist varies, or changes in the experiment. The dependent variable is what is measured or recorded and may or may not change as the independent variable is changed. A control group is a group that is not subjected to a change in the independent variable, so that any change in the dependent variable (for the experimental groups, compared to the control group) can be attributed solely to the change in the independent variable. On the basis of data

that are recorded, scientists will come to conclusions as to whether the data support or reject the hypothesis. It is never said that a hypothesis is proven true, because scientists recognize that further data or observations may change prior conclusions. When performing an experiment the larger the number of trials and the larger the sample size, the more reliable the data.

After many years of testing and study, the scientific community may develop a scientific theory, which is a concept that ties together many varied conclusions into a generalized statement.

Observing Pillbug Behavior

Make sure to wash your hands before and after handling pillbugs. Please handle them carefully so that they are not harmed. When touched, pillbugs will roll into a ball as a defense mechanism. They will recover shortly if left alone.

1. Obtain a pillbug in a tray. Examine the shell and body with the unaided eye and then with a dissecting microscope.

2. Examine the shell shape, color and texture. Note the number of legs and antennae. Try to determine whether it is male or female (females have leaflike growths at the base of some legs where developing eggs and embryos are held in pouches). Locate the eyes. Count the number of overlapping plates. Record the information below.

3. In the following space, draw a large outline of your pillbug. Label the head, thorax, abdomen, antennae, eyes, uropods (paired appendages at the end of the abdomen), and one of the pairs of legs.

4. As you watch the pillbug, identify behaviors that might protect it from predators, help it acquire food, protect it from the elements, and allow interaction with the environment.

5.Measure the speed of the pillbug. Place them next to a metric ruler and use a stopwatch to measure the time it takes for them to move a certain number of millimeters. Record your data below.

Pillbug	Millimeters Traveled	Time (sec)	Average Speed (mm/sec)
1			
2			
3			
4			

Formulating Hypotheses

Hypothesis are declarative statements that often include the word, "because". Hypotheses explain observations, and they are presented as though they are true (though they might not be true at all). Here is an example of a hypothesis.

Birds are able to fly, because they are less dense than air.

Observation

Explanation

Hypotheses logically lead to predictions, but hypotheses and predictions are two different things. Predictions are conditional statements that often are formulated in an "if...then" manner. Here is an example of just one prediction that is implied by the hypothesis given above.

If a flying bird is captured, and its density is measured, that density will be less than that of air.

Pause for a moment to be sure you notice the difference between a hypothesis and a prediction, because most students struggle with this and lose points because of the confusion.

Predictions are important, because they naturally lead to a way of testing the corresponding hypothesis. In other words, predictions allow scientists to design scientific experiments. If a predicted outcome does not occur for a properly designed experiment, that's an indication that the hypothesis is at least partially (and perhaps totally) incorrect. In that case, an alternative hypothesis must be formulated, and that will lead to other predictions and therefore other experiments. On the other hand, if a predicted outcome does occur, it simply means that the corresponding hypothesis MIGHT be correct (NOT that it definitely IS correct). Hypotheses are considered to be more and more probably correct as they stand up to repeated testing.

This is the basis of experimental science, and this is why we are gradually and continuously changing what we say is true about the world.

It is now time for you to employ the scientific method. You are going to test whether the pillbugs are attracted to, repelled by, or unresponsive to a variety of substances.

1. Choose two powders and two liquids to test. List them.

2. Write a hypothesis and a prediction for each substance you are going to test.

Performing an Experiment

Design an experiment to test the pillbug's response to your substances. The pillbug must be treated humanely; you may not pour anything on it or place it directly on a substance. For example, you could put the substance around the edge of the dish or on cotton balls.

A good experiment contains a control. A control group goes through all of the steps of an experiment, but lacks, or is not exposed to, the factor being tested. For example, water can be used for the control group rather than the liquid being tested.

Place 10 pillbugs in the center of your dish and record their movements over a 5 minute span for each substance you are testing.

1. List and label your independent variable, dependent variable, and any variables that you are controlling. Create one or more tables of data to record the results of your experiment on the back of this sheet.

2. Based on your data, what are your conclusions for each substance? Make sure to use the **data** to support your conclusions.

Review Questions

1. Which is more comprehensive, a conclusion or a theory? Explain.

3. Provide any example of a hypothesis for some everyday observation (or for any observation unrelated to pillbugs), then provide a prediction implied by that hypothesis.

4. Can data prove a hypothesis to be true? Explain.

5. Explain the difference between an independent and a dependent variable.

6. What happens to the accuracy of data as you increase the: A. sample size; B. number of trials?

7. What is the purpose of a control group in an experiment?