Termite Behavior: Focus on Experimental Design and Results  
(adapted from Surmacz, 2004 and Matthews and Matthews, 2012)

Prior to coming to lab this week, you should read all of the introductory information. Then, answer the questions on the back page of your laboratory handout (titled Case Study Questions). You will discuss the answers to these questions before beginning the laboratory investigation. The purpose of this case study is to give you practice thinking about how a good experiment is designed.

At the end of the laboratory you will be able to:
1. identify elements of experimental design in an example case study.
2. design appropriate experimental procedures that investigate termite behavior.
3. collect and analyze data from your group-designed experimental procedures.

Introduction

Biology is the science that studies living organisms and their interactions with each other and their environment. Living organisms have the following features: order; sensitivity; ability to use and transform energy; evolutionary adaptation; growth, development, and reproduction; regulation; and homeostasis, the maintenance of a relatively constant internal environment. While living organisms share basic characteristics, they are also very diverse. Living organisms come in a wide variety of shapes and sizes and by some estimates there are well over 5 million different kinds of organisms on earth!

As you might suspect, biologists study life in a variety of different ways. Scientists in our own Biology department here at UVM can be found investigating Chagas disease, fluctuations in mice populations in Vermont, spatial patterns in African savannah communities, signal transduction mechanisms during brain development, or the importance of competition in ecology, as a few representative examples.

These diverse activities share a common desire to understand the natural world through the process of science. In fact, the word science comes from the Latin word meaning “to know.” Science is a way of knowing that uses objective information to construct an understanding of the natural world (Moore, 1993). As we have discussed, there is no rigid, single “scientific method,” rather there are common approaches scientists use to study life. Biologists make observations, raise questions, construct hypotheses (possible explanations to explain these observations), conduct experiments to test their hypotheses, interpret results, draw conclusions, and pose further questions.

Each discovery in biology leads to further questions, making scientific inquiry a continuous and self-correcting process. Recently, the development of new techniques and innovative experimental approaches has yielded a phenomenal amount of new knowledge. We must remember that biology is not just a compilation of facts to memorize. It is a creative, imaginative, intuitive, and social endeavor.

The best way to learn how biologists do their work is to do it yourself. Experience is the best teacher! In this lab, you will explore the power of the scientific method to learn about living organisms. You will take the elements of the process of science discussed during lecture and explored in the pre-lab
activity and apply them to an investigation of termite behavior. During the next two weeks you will work your way through every part of the scientific process. Have fun!

**Termite Background**

Termites are small, light-colored, soft-bodied insects that live in moist, dark environments. Termites eat wood and can cause considerable destruction to various wooden structures. Their ability to degrade wood and other vegetation provides a nutrient supply for other organisms and makes them significant decomposers in the ecosystem. Did you know that termites do not digest the cellulose of the wood directly? The gut of the termite houses a protozoan that contains cellulase, the key enzyme for digesting cellulose in the ingested wood. This is a type of biological relationship where both organisms benefit from the relationship.

Termites are social insects that live in colonies and have a structured caste system. Most of the labor in the colony is accomplished by the workers. The workers are sterile and lack eyes. Their primary tasks are to collect food and to feed the other members of the colony (queen, soldiers and young). They do this by excreting food from their mouths and their anuses.

Given the destruction that termites can cause, it is of considerable importance to understand how termites identify and locate a food source. Is it by chance or do they use some sensory perception mechanism to find a new source of nutrition? Once a forager encounters food, it is also important to determine whether or how this information is conveyed to other members of the colony. You will have the opportunity in lab the next two weeks to address the first question.

**Essential elements of experimental design**

Scientists observe the natural world and pose questions. A possible explanation for a given observation is termed a **hypothesis**. A good hypothesis is in the form of a statement, is testable and is useful only if data could be collected to reject it. We cannot ever completely prove a hypothesis to be true or false. As a result, a crucial step in the scientific method is to design an experiment that allows us to clearly support or reject the hypothesis. This is one of the biologist’s most challenging and creative tasks. Biologists spend considerable time reading the scientific literature and critiquing other experiments before undertaking their own work. In designing a good experiment, scientists must define the variables, outline a procedure, and determine controls.

When designing an experiment to test a hypothesis, it is essential to identify and carefully consider the **variables**. Variables are the factors that may change during an experiment and they must be clearly defined and measurable. Variables fall into one of three categories.

a. **Dependent** – This is the variable that the researcher actually measures, counts, or observes. The **DEPENDENT** variable is what the researcher thinks will change in response to the experimental treatment.

b. **Independent** – This is the variable that is intentionally changed by the researcher. An **INDEPENDENT** variable is selected that the scientist thinks will affect the dependent variable.
Controlled – These variables are held constant between each group. By keeping CONTROLLED variables equal, this helps to prevent these factors from influencing the dependent variable.

The **procedure** refers to the actual method or particular series of steps used to conduct the experiment. When designing the procedure it is important to consider the presence of a control group (where the independent variable is zero or constant), the level of treatment (magnitude of the independent variable), the number of replicates (how many times the experiment will be repeated) and the sample size (what portion of the whole will be tested).

Lastly, remember that a good hypothesis is testable and can be either supported or rejected based on the data. It also can be used to **predict** the effect of the independent variable on the dependent variable. Predictions can be expressed in the form of if/then statements. (General form: If the independent variable is X and an experiment is conducted in which X is varied, then the dependent variables will be affected in this way.) Predictions are useful when evaluating the experimental results. If the results do not match your prediction then the hypothesis is rejected. If the results match, then the hypothesis is supported.

**Case Study: Lyme Disease** (based on information from Jones et al. 1998 and Kaiser, 1998)

Lyme disease is a prevalent pest-carried disease in the United States. If left untreated, it can lead to debilitating heart and nervous system problems and severe arthritis. A spiral shaped bacterium called *B. burgdorferi* causes Lyme disease. The bacterium is transmitted to people by a small, black-legged tick that feeds on deer and mice. A summary of the life cycle of the tick that carries Lyme Disease is shown in Figure 1.

The ticks’ hosts, the deer and mice, feed on acorns in oak forests primarily in the northeast and the western parts of the United States. A team of researchers observed that the acorn density of the oak forests in New York fluctuates from year to year and that mice populations in the forest were increased when the acorn density was high (Jones, Ostfeld and Wolff, 1996). These researchers asked, "If there are more acorns and mice in the forest, will there be a higher density of ticks that carry Lyme Disease?" They hypothesized that the number of ticks carrying Lyme disease would be high when acorn density in the forest was high. To test their hypothesis, the researchers studied six unfenced oak forest plots in New York (see Figure 2). Mice were initially removed from each plot by trapping. Four tons of acorns were added to three of the plots (with the help of some local girl scouts!). The remaining three plots did not receive acorns. Ticks were collected in 225 sections (15m X 30m) in each plot, and were identified and counted. The number of mice in each plot was counted also.
Figure 1: Summary of tick life-cycle.

Figure 2: Depiction of experimental design for Lyme disease Case Study.
Investigating Termite Behavior: Designing Your Own Experiments – Week 1

1. Make Observations
Working in groups of three (3), place a sheet of white paper in a plastic box. Use the brushes provided to transfer 3-5 worker termites from the NEW container to your box. Treat them gently, taking care not to crush them! Observe the termites as they move about the paper. If any attempt to leave the paper, gently nudge them back onto the paper with your paintbrush! After you are comfortable with handling the termites (about 2-5 minutes), use some of the pencils and pens available in the laboratory to draw lines or a fist-sized circle on your paper. Does the presence of a line or circle affect termite movement? Do the termites ignore the circle/line? Feel free to use additional paper if yours become overly cluttered up with lines. Your goal here is to explore, noting any patterns or interesting observations. Do not attempt to collect data or arrive at any particular conclusions. RECORD THREE OBSERVATIONS on the Lab Report page. Then, place the worker termites in the USED container.

2. Develop Hypotheses
Discuss your observations of termite behavior with your lab partner(s). Based on your observations, come up with a list of hypotheses about termite movement. For example, you might guess that termites usually travel in straight lines compared to squiggly lines. Remember that a good hypothesis is testable and can be rejected. RECORD THREE HYPOTHESES on the Lab Report page.

3. Select a Hypothesis
Pick one of your hypotheses to test experimentally, and record your selected hypothesis on the Lab Report page.

4. Design an Experiment
Design an experiment to test your hypothesis. Write a specific, detailed procedure on the Lab Report page. Consider what kind of data can be collected. If need be, timers are available to determine exactly how long the termites exhibit a particular behavior. Be sure to consider the following elements of experimental design and identify them in your methods section, if appropriate: dependent variable, independent variable, controlled variable(s), number of replicates, and magnitude of treatment. Prepare a table or chart to organize your data. Remember that a good experiment can be repeated.

5. Make a Prediction
Make a prediction based on your hypothesis and experimental design. Phrase your prediction in an if/then form and record it on the Lab Report page.

6. Collect Data
Conduct your experiment using NEW termites and following the procedure that you developed. Collect data from each test and record it in the table or chart you prepared in the last step. Record the results of all trials on the Lab Report page--do not eliminate any data!

7. Analyze Results
Examine your data and consider various ways to present the results. Some suggestions for data analysis include: calculating an average for each condition, providing a range for each condition,
graphing the results, and preparing a summary chart. Use extra paper or a computer to assemble your results.

8. **Draw Conclusions**
Based on your analysis of the results, reconsider your original hypothesis and prediction. Do you accept or reject your hypothesis? Explain why on the Lab Report page.

9. **Prepare to present your research**
Biologists share their findings with the scientific community. There are many ways to communicate--giving talks or presenting posters at professional meetings, participating in conferences, and writing papers for journals. Spend the remaining time in lab developing and designing a presentation you will share with the ENTIRE class at the beginning of lab next week. The presentation must include the following components:
   a. Observations
   b. Hypothesis
   c. Experimental methods
   d. Results

You may use the chalkboard or powerpoint or a combination of both to present your research. The presentation should be no longer than 3-5 minutes and each group member must participate.

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**Bibliography**
Image from [http://dpd.cdc.gov/DPDx/HTML/Frames/S-Z/Ticks/body_Ticks_three_host_cycle.htm](http://dpd.cdc.gov/DPDx/HTML/Frames/S-Z/Ticks/body_Ticks_three_host_cycle.htm)


Observations:

1.

2.

3.

Hypotheses:

1.

2.

3.

Hypothesis selected:

Experimental Design:
Description – 

Dependent variable –
Independent variable –
Controlled variable(s) –
Number of replicates –
Sample size –
Data collection:

Analyze results:

Draw conclusions:

Do you accept or reject your hypothesis? Why?
Case Study Questions – Turn in to your TA before leaving the lab (worth 5 points)

1. What is the KEY observation related to this experiment?

2. What is the hypothesis being tested? (Put it in sentence format.)

3. What are the dependent, independent and controlled variables?

4. Identify the control group, magnitude of the independent variable, the number of replicates and the sample size.

5. Write a prediction for the case study experiment.