Chapter 13

Expanding the Nature of Science in Teaching Laboratories: From ethology to investigating animal behavior

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Contents

Notes For Instructor
- Introduction....256
- Goals and Objectives....256
- Experimental Design....258
- Larsen and Meyer (1981)....258
- Preszler and Haas (2000)....258
- Preszler and Haas (2002)....259
- Prep Methods....261
- Materials....262
- References....263

Student Outline....263
- Morphological Observation....265
- Cricket Behavior....265
- Hypothesis formation....265

Experimental Design....266
- The Assignment Summary....267
- Literature Cited....267

Notes for Instructor

Introduction

While the primary goal of biology laboratories – providing students with hands-on opportunities to experience biology – has not changed in the last few decades, ABLE has helped lead a shift from observational exercises to experiments which include a broader range of scientific activities. I will describe how I have converted an observational exercise from the third ABLE workshop/conference (Larsen and Meyer 1981) to a hypothesis-testing experiment (Preszler and Haas 2000), and more recently to an open-inquiry exercise (Preszler and Haas 2002). In addition to considering the conversion of this specific exercise from descriptive observations of ethology to student-centered investigations of cricket behavior, I will discuss general principles which may be used to guide the conversion of descriptive exercises to more investigative experiments.

Goals and Objectives

Successful modification of laboratory exercises requires a long-term commitment of time and money. A healthy laboratory curriculum is similar to a healthy research program in that it should by dynamic rather than static. Exercises may be modified in response to changes in course goals, which should respond to changes in biological sciences, as well as changes in the needs and perspectives of student populations. Exercises also may be modified as novel ideas and feedback from assessments suggest better ways reach course goals.

The course goals of the New Mexico State University freshman biology course associated with this laboratory exercise are explained below.

"The primary goal of this course is for you to achieve a self-sustaining level of biological literacy. This means that by the time you have completed the course you should be able to apply concepts that you have developed in Biology 111L to subsequent biology courses, to courses outside the biological sciences, to personal issues, and to societal issues. You also should be able to read and critically evaluate new discoveries in biology as they are reported in the secondary literature. To attain such an advanced level of biological literacy you will need to develop the following skills and understanding.

- A critical understanding of scientific process.
- The ability to write and talk about biology with clarity and precision.
- The ability to make constructive contributions to group problem solving activities.
- An understanding of general principles of genetics, evolution, biodiversity, ecology, and behavior."

In order to make these goals more specific and operational, I have found it necessary to define what I mean by scientific process. It is through this definition of the specific components of scientific process that I have begun to more clearly see the difference between descriptive and investigative laboratory courses. The fundamental difference in these approaches, which drives the conversion of descriptive laboratory exercises to investigative experiments, is the increase in the components of scientific process included in teaching laboratories. Investigative laboratory courses (not necessarily every exercise) should include all of the following components of scientific process.

- Exploration involving initial observations, question formation, consideration of theory and analogous systems;
    - Hypothesis formation in response to these exploration activities;
- Experimental design of methods and predicted results;
- Observation and description of results;
- Evaluation of hypotheses by comparing predicted and observed results;
- Discussion of the implications of the experiment.

I have found that Larsen and Meyer's (1981) ABLE chapter "Animal Behavior Experiments Using Arthropods" has a variety of methods and observations which can be expanded into exercises which include all of the preceding components of scientific process. Their objectives are limited to two components of the exploration phase: making initial observations as a demonstration of general theories; students are not directly involved in the remaining components of scientific process. However, they provide students with a wonderful set of observational activities within these limited components of scientific process. In a single three hour laboratory students observe the following demonstrations:

- mechanoreception in cockroaches;
- chemoreception in flies;
- taxis and kinesis in isopods;
- aggression in crickets;
- courtship behavior in crickets and in fruit flies.

In order to convert Larsen and Meyer's (1981) exercise to a hypothesis-testing laboratory, I greatly reduced the initial observational activities to those relating to courtship behavior in crickets. This drastic reduction in the observational objectives of the exercise was necessary in order to provide time for the creative and synthetic student activities associated with forming and evaluating hypotheses. If the goals of a course include introducing students to the full range of scientific process, instructors need to sacrifice complexity and depth at some steps of the process, or focus the course on a small number of multiweek experiments and sacrifice the range of topics. In this case, I sacrificed the number of initial observations in order to make room for inquiry activities.

Experimental Design

In this section, I will provide an overview of methods from Larson and Meyer (1981) and from Preszler and Haas (20000), followed by detailed methods from Preszler and Haas (20002).

Larsen and Meyer (1981)

This major workshop from the 3rd ABLE conference provides detailed methods for a set of different activities. These methods are presented as demonstrations. Much of each system is set up by the instructor. Students conduct carefully prescribed methods, and make confirmatory observations. They observe and describe what they are expected to observe, if the methods have been conducted correctly. In spite of the constraints of this approach, students are given the opportunity to observe the following very interesting behaviors of arthropods in the laboratory.

- ♦ *Cockroach reflex behavior:* Students decapitate cockroaches and observe reflex escape behavior of cockroach leg muscles in response to stimulation of cerci.
- ♦ *Isopod taxis and kinesis:* Students observe pill bugs in arenas with various specified combinations of light and humidity treatments. They observe directional negative phototaxis in response to light, and a non-directional reduction in the intensity of locomotory activity, kinesis, in response to increased humidity.
- ♦ *Cricket aggression and courtship behaviors:* Students observe aggressive interactions between pairs of male crickets, and courtship behaviors when females are added to arena.
- ♦ *Blowfly chemoreception:* Students expose starved, but fully hydrated, blowflies to a series of sucrose solutions to determine the minimum sugar concentration required to elicit feeding.
- ♦ *Drosophila courtship:* Students transfer fruit flies to a courtship chamber and describe the fly's sequence of courtship behaviors.

Preszler and Haas (2000)

We chose one of the systems, cricket aggression and courtship behavior, presented by Larsen and Meyer (1981) and converted it into a hypothesis-testing experiment which included the following components of scientific process:

Hypothesis Formation

In the introduction, we provided students with theoretical background information about dominance hierarchies and their relationship to mating behaviors. We then provided students with two alternative hypotheses:

1) "Dominance Helps Hypothesis": A dominant male is able to outcompete subordinate males for access to females, and females derive some benefit from choosing dominant males as mates.

2) "Dominance Hurts Hypothesis": In spite of a dominant male's potential to outcompete subordinates for access to females, females derive no benefit from choosing dominant males as mates.

When we asked students to consider these two hypotheses, we found that they easily accepted the first hypothesis, and dismissed the second. In order to address this problem, we summarized some of the results from a review article by Qvarnstrom and Forgsen (1998), which presents a number of arguments explaining why a male's position in a dominance hierarchy is often not correlated with mating success.

Initial Observations

We first asked students to observe cooled, immobilized, crickets through a dissecting microscope to introduce them to insect morphology, and perhaps more importantly, to help them begin to appreciate insects as complex organisms rather than "disturbing little wiggly things."

In a second set of initial observations, students mark individual male crickets with various colors of liquid paper correctional fluid, put them in a common arena, and record interactions between individual males. Students then construct a dominance hierarchy of the males based on these observations.

Predicted Results

Once students have identified the dominance hierarchy of the group of male crickets, they are ready to specify the predicted results of each hypothesis. What does each hypothesis predict will happen when they add female crickets? Which males will be first to mate with the females?

Observed Results

Students add female crickets to the arena and carefully observe and record mating behaviors.

Evaluation of the Hypotheses

Students write a lab report in which they describe their observations, their conclusions regarding each hypothesis, and the implications of these conclusions.

Preszler and Haas (2002)

In an effort to allow the students to participate in the more creative components of scientific process, hypothesis formation and experimental design, we rewrote this exercise using an inquiry-based approach. The fundamental changes between this approach and the previous hypothesis testing exercise are that now the students form their own hypotheses and design their own experiments. Experiences associated with converting other exercises to an inquiry approach have taught us that successful student hypothesis formation and experimental design requires a carefully considered lesson plan and teaching strategy.

In order for students to generate hypotheses they must first be engaged in exploratory activities: initial observations, question formation, and consideration of general theory and analogous systems. In the introductory section of the student exercise, included later in this chapter, we introduce students to general theories of dominance hierarchy and of mate choice behaviors. In this introduction we emphasize examples that are familiar to students, such as House Finches. However, before asking students to form hypotheses, it is necessary to completely awaken their curiosity by letting them make observations of a living organism. We do this by cooling down crickets until they are nearly immobile and having students observe them through dissecting scopes and draw a sketch of their observations (the prep guide explains how to set this up). The change in students' attitudes is very obvious as they begin appreciate the amazing complexity of insect morphology. At this point groups of students consider a set of prompts in brainstorming sessions as they generate hypotheses (see Hypothesis Formation section of student exercise).

Once a group has generated a hypothesis, they are ready to design an experiment and determine the predicted result of their hypothesis. We provide them with a brief description of general characteristics of potential independent and dependent variables which might apply to their experiment, and we ask them to have their TA review their written proposal of how they will manipulate their independent variable, how they will observe their dependent variable, and what they have determined is the predicted result of their hypothesis, prior to conducting their experiment. This process of exploration, hypothesis formation, and experimental design may take up to an hour of class time. As an instructor, it is sometimes hard to accept that if we expect students to think creatively and synthetically about science, we need to dedicate sufficient time to these important activities.

As students begin to observe the social behavior of crickets, their initial impression is that there is very little social behavior among crickets. For the first few minutes, crickets may be more interested in escaping than in interacting with each other. If the lighting is too bright, or if students are making noise or moving around, the crickets may hide from the "big scary predators," rather than interact with other crickets. If the students have put too much Liquid Paper on crickets (more on this in the prep notes), the crickets will be too busy trying to get the paint off their wings. Lastly, observing animal behavior is very subtle and challenging and it takes time to learn to notice the body language of a cricket.

As I talk to students and attempt to teach them to notice the subtle and revealing details of animal behaviors, they often make statements such as "the yellow cricket is mean" or "the blue cricket is a wimp". Encourage and even attempt to elicit these statements by asking questions such as "what do you think of the white cricket?" Use these initial conclusions that students have jumped to about individual crickets as keys to help them notice what they are seeing. If a student tells me a particular cricket is shy, I say "Great, now tell me exactly what that cricket is doing that gives you the impression it is shy." This helps the students realize that they are observing subtle behaviors; their problem is that they are simply combining these observations into an overall impression without noticing and documenting the observations that are the foundation of their conclusions.

Since each group is evaluating a different hypothesis about the same general topic, it is extremely valuable to have each group present their results and discuss their conclusions. This allows them to learn to draw conclusions and discuss implications with guidance from the entire class, rather than having to figure out how to do this on their own, as they attempt to write the discussion section of their laboratory report. If you have time for these short informal presentations at the end of the period, students can cite the conclusions of other groups as they write their discussion.

Prep Methods

If the tubs containing the crickets are kept clean and dry, the prep methods for this exercise are not very demanding considering that it enables many sections of large courses to observe animal behaviors.

Set up by the Prep Person

When the crickets arrive, put approximately 500 crickets in each 19 gallon Rubbermaid Fresh Top tub. For a course with 12 sections (24 students per section) that meets over a period of 5 days we order 1000 crickets. The crickets in each tub need a place to hide, a water source, and food.

In order to provide the crickets with cover that reduces cannibalism and generally keeps them healthier, put about 20 slightly crumpled paper towels in the main part of the tub.

Water must be provided using a method which does not allow crickets to drown themselves. I put some "Cricket Quencher Original," a gel substance sold by Fluker Farms, in a Petri plate in each tube. These need to be changed about every other day. Alternatively, soak a big handful of absorbent cotton in water and gently squeeze out the water so that it is damp but not dripping, and set the damp ball of cotton in one end of the tub. Set a test tube rack in front of the gel or the cotton so that the paper towels don't touch the damp cotton or gel as they expand. One reason I prefer the gel is that it does not build up the humidity, and associated smells, in the tub as much as damp cotton.

For food, sprinkle in one-half cup of Fluker's Cricket Chow in each tub (chick food also works fine), away from the water source. Pieces of potato or carrot also work, but they tend to get moldy.

Sort the crickets into male and female tubs at least 2 days before the first lab. The most obvious difference between males and females is the ovipositor, which is present only in females. Sorting the males and females is a tedious job for one or two people, so I ask all the instructors to come in and help out.

Every day, replace the paper towels. Add some Cricket Chow, if they are running out. Make sure the food and the paper towels stay dry. Every other day, replace the Cricket Quencher.

Instructor Prep

When each instructor arrives at the lab, they should put the crickets that will be used for morphological observation in a beaker and set it in the ice during the introduction (about 15 minutes), by this time the crickets will be nearly immobile.

Before leaving their laboratory, each instructor should make sure the crumpled papers towels in the cricket bins are clean, dry, and not touching the Cricket Quencher.

Student Methods

It is not unusual to have students who are initially intimidated by crickets. Sometimes this reflects a real, although admittedly irrational, phobia; in other cases, individuals are simply trying to make a scene. I typically find that if I assure students they won't necessarily have to touch the crickets, but that I would like them to do their best to observe the crickets, they calm down and begin to get interested. Rarely (about 1 out of 2000), we have a student who is clearly pale and sweaty and struggling to keep from panicking. In these rare cases, I arrange an alternative assignment.

The hardest step for the students is marking the crickets. Be sure they use a toothpick rather than the liquid paper brush to make small marks on the thorax, not on the wings. Mary N. Puterbaugh

Mulcahy describes a method of marking insects with fluorescent dust in her chapter in this volume. It might avoid the mess associated with trying to touch crickets with a bit of liquid paper.

Materials

Equipment

- Cricket Tubs. We store 500 crickets in a 19 gallon Rubbermaid Fresh Top tub. You will need separate tubs for males and females as well as used males and used females (which can be reused after they've rested for a few hours).
- Observation Aquaria. We use 10 gallon glass aquaria with a small amount of natural colored gravel in the bottom of each. These can be purchased at pet stores for less than $10.00 each. Our maximum group size in this experiment is 4 students. We cover each tub with blue poster board.
- Dissecting microscopes (1 per student).

Supplies

- Crickets. I use 1000 adult crickets from Tophat Crickets (phone 616-327-2988; cost approximately $32) for a course with 12 lab sections with 6 groups in each section. We pay the extra $15 to have them shipped Airborne Express to reduce the shipping stress.
- Cricket Quencher Original. Fluker Farms 1-800-735-8537. <http://www.flukerfarms.com/explore.htm> They also sell healthy inexpensive crickets, but in our experience the crickets from Tophat mate more readily.
- Cricket Chow. Fluker Farms 1-800-735-8537. <http://www.Flukerfarms.com/explore.htm>
- Petri plates (2 sleeves of plates can be re-used across sections).
- Ice.
- Paper towels.
- 8 beakers, 200-ml.
- Liquid Paper®, 5 different colors or flourescent dust from Radiant Color Company <www.radiantcolor.com> series R-103-G; and Day-Glo Color Company <www.dayglo.com> Product Arc Yellow (orange) A-16. These companies may vast quantities of flourescent dust and may provide you with a free sample.
- Toothpicks. Ideally, use wooden ones with a rounded rather than sharp end.

Time considerations

We have asked Tophat to have the crickets arrive 4 days before our first cricket lab (9 days before the last one) and they have been very dependable. You don't want the crickets to arrive too early or else they will be old by the last lab, but you need time to sort them and time for an emergency shipment if there are any problems with the first batch. The exercise takes 2.5 to 3 hours.

References

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Student Outline

As winter turns to spring, the early morning air begins to fill with the wonderful songs of male birds. These males are often perched on a fence post, or a tree top, so that they can display their bright colors to maximum advantage as they sing at the top of their lungs. But just what is the advantage they are attempting to achieve? If you crawl out of bed early enough to watch their performance, you might see, as you would expect, that they sing and display their bright feathers when a female is near; more surprisingly, they also sing and display when a second male approaches. The second male often responds with a song of his own. Why, in the midst of the mating season, are these males so intent upon singing and displaying to each other? In your laboratory exercise, you will consider strategies of social behavior exhibited by a variety of animals. After making some initial observations, you will work with your laboratory group to create a hypothesis, and design and carry out an experiment using the house cricket, *Gryllus domesticus,* to test your group's hypothesis.

If your curiosity got the best of you and you began to spend some time each morning watching male birds to try and understand their behaviors, you would soon notice, that from one morning to the next, you couldn't be sure that you were watching the same males. Even trained ornithologists have this same problem as they attempt to keep track of individual birds. They typically solve their problem by attaching color-coded bracelets to the bird's legs. You will be faced with this same problem as you begin to work with the crickets. Rather than trying to attach bracelets to cricket legs, you will simply put a dot of colored dye on their thorax. This will allow you to design an experiment that includes keeping track of the behaviors of individual crickets as they respond to different social or environmental situations.

Once you could keep track of individuals, if you watched either the birds or the crickets very carefully, and kept an accurate record of your observations, you would begin to see patterns in interactions between pairs of individuals. You would soon discover that some individuals appear to consistently dominate others. You would have uncovered one aspect of the social structure of the population, the dominance hierarchy. Many social animals develop and maintain dominance hierarchies (*e.g.* baboons, elephant seals, chickens, pinyon jays, and crickets). A **dominance**

hierarchy is a social ranking in a population or group of individuals of the same species. An individual's ranking is based upon his or her strength and influence over other individuals. Dominance hierarchies are established and maintained through frequent assessments of the strength of potential competitors. Evaluation of a competitor's strength is typically made through observations of ritualized behaviors and display, such as postures that display their size, songs that emphasize their endurance and strength, or even displays of the brightness of their colors.

What are the costs and benefits to individuals who participate in the development and assessment of dominance hierarchies? The most obvious benefit of dominance hierarchies is that they reduce an individual's chance of getting injured in a fight over resources. However, the cost associated with accepting dominance hierarchies can be very high, for some individuals, in some situations. For example, if dominant individuals are always guarding a resource, and if a submissive individual always backs down when confronted with one who is dominant, the submissive individual might starve. This suggests that the cost, to submissive individuals, of accepting a dominance hierarchy might depend on the ability of dominant individuals to guard resources which could be influenced by the distribution of the resource.

Relationships between dominance hierarchies and mating success are even more complex than relationships between dominance hierarchies and resources. Males often engage in displays of dominance to other males that might be associated with determining access to mates. However, in many species, access to mates is not sufficient. Females often choose between competing males, and they sometimes use the quality of a male's dominance displays as the basis of their choice. If males are assessing each other's rank in a dominance hierarchy, they may be determining who has access to a resource, they may be determining who has access to a female, and they may be trying to influence a female's mate choice.

In some species, the relationship between male dominance hierarchies and mating success is quite obvious and contains few surprises. For example, there is tremendous variation in size among male elephant seals. Groups of males have well established dominance hierarchies and the most dominant males copulate far more often with the females (McCann 1981).

However, as biologists began to closely observe the social structure of many different species, surprising observations began to accumulate (Qvarnstrom and Forsgren 1998). If we return to those birds singing outside your window, we may find some interesting results. House finches are very common birds in many suburban areas across North America. There is variation in the brightness of the red on male's chest and head. The red pigment is associated with the quality of the males' diet and so brighter males tend to live longer, they have fewer parasites (this is a big issue with birds), and they are preferred by females. However, if you watch interactions between male house finches you might find that brighter males are submissive to males with less color (McGraw and Hill 2000). There is a negative association between the position of a male in the male dominance hierarchy and his mating success! It may be that brightly colored males already have access to food (this is what makes them bright) and they have high mating success (females prefer bright finches), and so, they have little to gain by attempting to establish their dominance over other males. The less brightly colored males, on the other hand, have little to lose by attempting to establish dominance. This risk assessment of dominance behavior varies between individuals, between environments, and also between species. Before your group proposes a hypothesis about dominance hierarchies, let's first become familiar with the species that you will be experimenting with.

Morphological Observation

In the initial step of today's activity, you will observe the external morphology of male and female crickets through a microscope to identify structures associated with social communication and reproduction.

Insects are **ectothermic** which means that their body temperature is similar to their surroundings. Your instructor has cooled some house crickets so that they will hold still while you observe them through the microscope. At low temperatures they are immobile, but not dead; if you handle them gently, they will be ready to hop around as soon as they warm back up. You will work individually during this part of today's activity.

Like all other members of the **class Insecta,** adult crickets have a segmented body grouped into three regions: **head**, **thorax**, and **abdomen**. Two segmented antennae are attached to the head, six legs are attached to the thorax, and in many insects (including crickets) the thorax has two pairs of wings.

Methods of morphological observations

1. Set up a dissecting microscope. If you have any questions about how to use the microscope, refer to the previous chapter. Adjust it so that the light is shining from above.
2. Set the cool cricket in an open Petri plate filled with ice that is covered with a paper towel. You may want to set the clear lid over the cricket.
3. Set the magnification of the objective lens to the lowest number possible.

Observations

1. Draw an illustration of *Gryllus domesticus*.
2. First label the 3 major regions of the insect's body: **head**, **thorax**, and **abdomen**. Focusing on the head, label the **antenna**, **compound eye**, and the following 2 mouthparts, the **mandible** and **labium**. Moving back to the thorax, label a **wing**, and on a leg label the **femur**, **tibia**, and **tarsus**. Label the two **cerci** (sing. cercus) that project out from the posterior end of the abdomen, and, only if you are observing a female, label the long **ovipositor**.
3. Write notes next to your labeled illustration, indicating how some of these structures might influence how the cricket perceives and responds to its environment. If you are observing a male cricket, look at a neighbor's female cricket; if you are viewing a female, look at a neighbor's male.

Cricket Behavior

Your group will develop a hypothesis concerning dominance hierarchies. You will then design an experiment that involves observing the behavior of crickets in different conditions in order to test your hypothesis.

Hypothesis Formation

Your group will now need to brainstorm and develop a set of tentative hypotheses. Then as you discuss your experimental design, you can narrow your project down to a single hypothesis that you find interesting, and that you will be able to test by observing crickets in different situations. Work through the following questions with your group. Your answers to these questions will not be graded; they are meant to be used as prompts that may help you arrive at an interesting hypothesis.

1. What resources are important to crickets living in an aquarium? If dominance hierarchies influence access to resources, how might the distribution of resources influence interactions between crickets?
2. If dominance hierarchies influence access to mates, how could the social structure of a group of crickets influence the intensity or number of displays? How would your answer differ if dominance displays were meant to influence mate choice rather than access to mates?
3. How and why might dominance behaviors differ between males and females?
4. How and why might crowding influence dominance behaviors in males? In females? In groups of males and females?
5. If participation in a dominance hierarchy is an adaptive behavior for individuals (notice the benefit is for individuals, not necessarily for the group), under what conditions might crickets choose not to participate in these hierarchies?
6. Write your group's hypotheses.

Experimental Design

Read through the following section and then design the details of your experiment and determine the predicted results of your hypothesis. Before you begin be sure to go over your experimental design with your instructor, including the following components:

- hypothesis,
- description of your independent variable,
- predicted result, and
- the design of data tables.

Your experiment will most likely include placing crickets in one situation in the aquarium, recording their behaviors, then modifying the situation, and again observing and recording cricket behaviors. You will want to set up the situations, or treatments, in a manner that will allow you to compare your observed results to the predicted results of your hypothesis. This means that you must design your treatments so that one observable result will occur if your hypothesis is supported, and a clearly different result will occur if your hypothesis is false. In your two treatments you will manipulate the level or intensity of your independent variable. In the following space, identify your group's independent variable, and describe how you plan to manipulate it.

One of the difficult challenges of conducting experiments that evaluate animal behavior is observing and recording the dependent variable. Animal behavior tends to be characterized by long periods of very subtle behaviors punctuated by moments of intense activity. Television shows illustrating animal behavior tend to show these moments of intense activity, such as a lion chasing a gazelle, without showing the person behind the camera waiting in a blind for days as the lion slept, and scratched, and walked aimlessly around the savannah. You will need to develop patience and attention to detail as you record your dependent variable, characteristics of crickets' behaviors.

In each situation, you will probably want to describe the intensity and outcome of the interactions between pairs of crickets. Sometimes crickets interact very aggressively by biting or kicking. More often, cricket behavior is much more subtle and must be observed and recorded carefully. Two crickets may touch each other with their antennas **(antennate)** or males may **stridulate,** rubbing their wings to call or sing. If one cricket convinces another to leave his position, he has **displaced** a potential competitor. If they mate, the male will crouch down so that the female can climb onto his back. He will then curl the tip of his abdomen up and transfer a small white packet of sperm (**spermatophore**) to the female.

Consider your independent variable, and your dependent variable as you design your data tables, which will help you organize your observed results.

Before you begin recording your observed results, you need to specify the results predicted by your hypothesis.

Notice that as you record your observed results, you may need to be able to recognize and keep track of individual crickets by their color codes. Use the following method to very carefully put a small dot of color on the crickets that you plan to observe.

1. Use a beaker to collect crickets and put them in your observation bin.
2. Mark the crickets so that you can recognize individuals. Gently hold each cricket, while your partner uses a toothpick dipped in correction fluid or florescent dye to mark each cricket with a different color or pattern. Mark the crickets on the dorsal (top) side of their thorax, but do **not** let the correction fluid touch their wings. It is critical that you use a small dot of fluid or dye when marking the crickets. If you use too much, you will gum up their wings and you will spend the rest of the period watching them try to scrape it off.
3. After you complete your observations, put the male crickets in the large tub labeled "used males." Put the female crickets in the large tub labeled "used females."

The Assignment Summary

- ✓ Draw and label the external anatomy of a cricket.
- ✓ Write a methods section. Be sure it carefully describes how you set up your independent variable and how you observed the dependent variable. It should be written as a description of your experimental design and a record of your methods; it should not be written as a set of instructions.
- ✓ Write a results section. This section should present an organized description of your observations of cricket behaviors. Try to use the anatomical vocabulary from your cricket illustration in your descriptions of cricket behavior.
- ✓ Write a discussion. This section should include a conclusion and a discussion of the implications of your conclusion.

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