Individual research project: Each student will design, execute, describe in a manuscript, and present to the class an individual research project. My expectation for these projects is that you formulate a simple, straightforward question (or set of questions) that can be answered by making qualitative observations or collecting quantitative data. Your project may be observational or experimental, laboratory or field, or some combination of these methods. In general, the individual research project will generate a quantitative data set and a statistical analysis that results in conclusions about a specific question or hypothesis.

When collecting data on behavior it is necessary to have at least one specific "behavioral assay," which is a type of behavior or ecological feature that is easily recognized, and that can be counted, measured, or quantified in some other way. The possibilities for this are almost endless. As you will see in lab, we might count the number of individual birds in a flock that are doing a certain thing. For a foraging heron, we might estimate distance from shore or depth of water in which it is foraging. We might time how long honeybees spend on a specific type of flower. For any type of behavioral assay, it is necessary to have replicated observations, meaning numerous observations of different individual animals doing the same thing. The reason for replication is that it allows us to perform statistical tests on our data.

The most straightforward way of collecting behavioral data for statistical analysis is to make some comparison between two or more categories. As you will see in lab, we might compare the behavior of two different species in similar habitats, the behavior of females with that of males, the behavior of a single species in two different habitats, or the behavior of a single species under different environmental conditions. The possibilities of comparison can be complex, but for the purposes of this course, a simple comparison is best. A simple comparison would be one with only two categories, as described above. Do not try to execute a project that exceeds the time or energy available. The goal of this project is to learn about the process of doing science more than to actually do some serious science.

The combination of comparison of categories and replicated observations of a specific behavioral assay will allow you to assess the validity of your hypothesis with a statistical analysis. We will discuss in class how the results of a statistical analysis can be interpreted to convince fellow scientists that your conclusions about the validity of your hypothesis are correct. You will describe the results of your individual research project in a manuscript and in an oral presentation. I will evaluate the former, and I and your fellow students will hear and evaluate the latter.

The style of writing used in scientific manuscripts in behavioral biology (an in many other disciplines within biology) has changed over the last couple of decades. As far as I can tell, other fields in science have failed to keep up. In this course, writing should be in first person using active voice. Such writing is clearer and more concise than third person using passive voice. There is no reason to be dishonest or unclear about who did something, when it was done, and what we learned from it. Description of results of your study (either the individual research project or the lab reports) should be clear, direct, and forceful statements about the important findings of your study.

The manuscript describing your project will be prepared in the format used in scientific journals. The manuscript must be computer word-processed (submitted as an MS Word document or as a PDF), double spaced, with margins of approximately 2.5 cm, in 10, 11, or 12 point font (preferably Arial, Georgia, Helvetica, or Times), in plain and not boldface type. Use underlining or italics for scientific names of study organisms. You may use common names for plants in habitat descriptions.

- The brief yet informative **title** comes first. It should be centered at the top of the first page and followed two lines below by your name, the date of submission, and your campus box number, also centered. Titles should be assertions which tell the readers something about the results, rather than descriptions which do not (e.g "Alate fire ant queens are virgins" vs. "Aspects of the foraging behavior of *Trimerotropis saxatilis*"). Left-justify everything below your campus box number.

- The **Introduction** begins two lines below your campus box number; **do not** use a heading for the Introduction. The introduction lays the groundwork for the questions that you address and their significance in the light of behavioral and evolutionary theory (as discussed in readings and in lectures), and in light of recent work. This means that **you must cite at least one original research report** in your manuscript. Original research reports are articles in which the author(s) present original data and interpretations that have not been previously published. Original research reports are found in scientific journals (e.g. *Science*, *Animal Behaviour*, or *Behavioral Ecology and Sociobiology*, **NOT** *Natural History*, *Psychology Today*, or *Discover*). **The introduction should begin with general conceptual background** on your question and move to more specifics, and end with a concise statement of the purpose of your investigation.

- The **Methods** section discusses the practical aspects of your work, including where and when you collected your data, and specifically how you collected data. Begin the Methods section with a heading. Most manuscripts need a “Natural History” subheading within the Methods, which succinctly describes pertinent aspects of the biology of your study animal. Some of this information will come from your own observations and some will come from field guides or taxonomic treatments of the animal group. Manuscripts about field projects should include a concise description of the locality and habitat (including abiotic, biotic, and social environmental conditions) in which your observations occurred. For lab projects, include information about your lab set-up, conditions, experimental manipulation and controls, and observational protocols. Both types should include qualitative descriptions of your “behavioral assays.”

- The **Results** section presents your qualitative observations and descriptions of behavior patterns (with accompanying line drawings if you wish), and your quantitative data (in text supplemented by tables or graphs) and statistical analyses. My preference for the format of the Results is that you describe in writing (with clear, bold, and direct statements) your important results, and either report statistical tests in the text or refer the reader to figures or tables (if needed) to supplement your text. You should use a heading for the Results section, and some manuscripts will need subheadings within the Results section. See the “Lab Report Checklist” for more information about presentation of results, and the handout on “Statistics for Novices” for information on constructing tables and graphs, and on performing, and presenting the results of, statistical analyses.

- The **Discussion** section is where you interpret your data and statistical analyses, and draw more general conclusions from your work. Do not repeat results or refer to figures or tables. Make reference to evolutionary and behavioral theory that we have discussed in class; do the answers to your questions fit current ideas about the mechanisms or adaptive significance of behavior? Use the comparative method and the concepts of divergent evolution and convergent evolution if appropriate. A citation of previous original work is appropriate here.

- Any conceptual or substantive help that you received from faculty or fellow students, access to private or public lands, and any financial assistance in conducting your study should be acknowledged in an **Acknowledgments** section. Some behavioral biologists use this section as a way to introduce humor into their scientific writings; for instance, one group of

authors stated that the order of authorship of their paper was determined by fisticuffs (who knows, maybe it was!).

- These main text sections will be followed by a **References** section which contains bibliographic information, in standard scientific format, on the works that you cite in the text. The standard procedure for citations in the text is to cite the last name(s) of the author(s), and date of publication, of the source of the information to which you are referring (e.g. Emlen and Oring, 1977; Darwin, 1871). For articles with three or more authors, cite in the text the first author's name followed by "et al"; all authors are then listed in the References section. In the References section, full bibliographic information is given, in the format that follows. References should be in alphabetical order within the References section.

  Bibliographic format for journal articles:
  - Author(s) Last Name(s), Initials, Date of Publication. Title of article. *Title of journal*, volume: page numbers of article

  Bibliographic format for books:
  - Author(s) Last Name(s), Initials, Date of Publication. *Title*. Publisher, Place of Publication

- The **figures** (with captions below) and **tables** (with headings above) come last.

A separate document ("Research project advice") provides suggestions for projects, a list of the materials, equipment, and field sites that are available in the department, a list of journals available in the library, and ways to access literature that is not in our library. I will also provide a checklist of the criteria that I use in grading project manuscripts ("Research project checklist"); refer to this when preparing your document.

Although I said above "individual" project, it is possible for you to work in small groups (two or three students) on sets of related questions. For instance, a group might collaborate on an investigation of seed-harvester ants. One student might investigate the relationship between time of day and forager recruitment, another might study the effect of temperature on running velocity, and another might study the effect of load on velocity. Discussion of questions with your colleagues helps to refine and sharpen them. Each student might help the others with design of protocols and data collection, and all could have their data in a short period of time. Analyses of the data might use similar statistical tests. Finally it is very helpful to have colleagues evaluate your statistics and criticize your writing before you submit it to an editor (or to your instructor). I do not view this type of collaboration as plagiarism; in fact, this type of interactive ability is an important skill for scientists to develop. Be sure to acknowledge the assistance of colleagues in your manuscript. You may also cite the work of fellow students in your manuscript; see me for the proper format for such citations.

A brief statement of your intended questions and methods, and a brief description of the natural history of your study organism, is due electronically on **Monday, 5 October**. This should be no more than two or three short paragraphs in length. The purpose of this proposal is so that I know what you are planning, and so that you receive input from me and from your colleagues early in your project. It is a good idea to talk to me informally before finalizing your plans to avoid duplication of efforts. Data sets are due on **Monday, 23 November**, so that you can get my input on statistical analyses. Final drafts of your manuscripts are due by 5:00 pm on **Monday, 7 December**. Late project manuscripts will be accepted but will be penalized by the deduction of 20% from the possible points for each day that the manuscript is overdue (including weekend days).

Presentation of project report: During our last two laboratory meetings (**Monday, 30 November and Monday, 7 December**), each student will present to the class the results of the research project. These presentations will be no more than 10 minutes in duration, and should

consist of a brief statement of your questions, a description of the natural history of your study animal and of your methods, a presentation of your results and statistical analysis, and the conclusions that you have drawn. We will strive to have time for questions after each presentation. Most students use powerpoint to make these presentations but this is not required. Whatever medium you use, some sort of visual aid such as slides or overheads is appropriate. I can assist in preparation of these items if need be. Images of your study area or apparatus, and of your study animals, are good visual aids for your audience. Graphs or tables of data are also useful. I can make digital photographic equipment available to you for capturing pertinent images. These presentations will be held in MS 301, where we have the necessary technology for making this sort of presentation.

My preference for the way to approach a presentation like this is to tell your audience a story. Don't read us your manuscript – we can do that ourselves. Tell us what you did and why. What did you find out? Why do you think it is important or worthwhile? What problems did you have? What practical things did you learn (like “don’t stand in a fire ant mound while watching birds!”)? Be calm and informal -- tell us your story, and remember that we are all in this together. A separate document (“Advice on presentations”) provides more information on the presentations.