Guidelines for Scientific Papers/Lab Reports
developed by the Biology Dept. at Davidson College

Note – more information on writing lab reports can be found in *A Short Guide to Writing About Biology* by Jan A. Pechenik, as well as at the LabWrite online resource from NC State (http://www.ncsu.edu/labwrite/).

Writing a laboratory report is like writing an original research paper. Scientific papers are usually written in a format with the following sections:

Order of Sections in Paper	Order for Writing Sections
Title	Figures
Abstract	Results
Introduction	Methods
Methods	Discussion
Results (imbed figures for lab reports)	Introduction
Discussion	References
References	Abstract
Figures (when submitting for publication)	Title

Abstract

An abstract is a single paragraph summary of your experiment. Like a paper (or lab report), an abstract should contain an introduction, methods, results, and conclusion. Every scientific paper has an abstract at the beginning to let the reader know what the paper is about and to make an informed decision whether the entire paper is worth reading. Abstracts also are printed in reference books and available on line where the whole article does not appear, and are used to decide which articles you need to obtain. A third use of abstracts is to summarize the work you will be presenting at a meeting, so people will know if they should come to see your complete presentation. Thus the abstract is absolutely critical and requires very careful thought in the writing process. FYI most scientific journals limit abstracts to 150-500 words.

Guidelines for writing good abstracts: Revise, revise, revise. The Abstract should be clearly and concisely written. Try to address each of the questions below (under ABSTRACT). Use plain English whenever you can, active voice when you can, and use simple sentences. It is not necessary to refer to any literature (if you do, list the references below the abstract). State only your most important conclusion(s). Remember, the abstract will likely be the only portion of your report that most people read. Make sure it is well written.

1. Title: The title should indicate the question you investigated, or the method, if that is important. Example: Effect of Owner Education Level on Number of Cats per Household.
2. Author(s) and address(es). Example: Mary Darwin, Polly Merase, and John D. Helix, Biology Department, Davidson College, Davidson, NC 28035.
3. What is the general topic you were investigating and why is it important? One to two sentences. Example: Education level may affect choices people make about their personal lives and habits.
4. What are the specific questions you are addressing with this project? The abstract should not include your complete methods. Provide a one or two sentence overview. Example: We investigated the relationship between education level and the number of cats per household

for residents of a small town.

5. How did you do this experiment? For a single paragraph abstract, one or two sentences are
6. needed. You are not trying to be complete, just give a general idea of how you did it. Example: The residents of a small town in North Carolina were polled as to the number of years of education for adults in households and the number of cats associated with the household.
7. What did you observe? One sentence should be enough: state only your main point(s). Example: Adults with either low education levels (0-10 years of school) and those with high education levels (more than 16 years of school) had significantly more cats per household than those with intermediate education levels (11-16 years of school). Include your most important data (mean values, standard deviations, number of samples you studied, *etc.)* that influenced your conclusion.
8. What did you find out about the general topic or question (see #3 above)? One sentence, 2-3 sentences for a longer abstract. Example: We concluded that education level can affect choices not directly associated with academic pursuits.

Here is the final abstract from the example above:

> **Education Level is Associated with the Number of Cats per Household**
> Anna Author and Aaron Associate. Biology Department, Davidson College, Davidson, NC 28035.
>
> Education level may affect choices people make about their personal lives and habits. We investigated the relationship between education level and the number of cats per household for residents of a small town. 156 adult residents of a small town in North Carolina were polled as to the number of years of education for adults in households and the number of cats associated with the household. Adults with either low education levels (0-10 years of school) and those with high education levels (more than 16 years of school) had significantly more cats per household than those with intermediate education levels (11-16 years of school) when analyzed by the statistical test ANOVA, ($p<0.005$). This finding is highlighted by noting that those people with high or low education levels were more likely to have four or more cats (23%) than those people with intermediate education (4%). We concluded that education level directly affects whether a household will include pet cats.

With the method outlined above, you should be able to produce a good abstract in less than an hour. If you haven't clearly and carefully thought through what you did in the experiment, writing the abstract should help you do so. It is shorter than a lab report, but includes most important points. (For your information, the study and abstract above was invented for this lab and does not reflect an authentic study.) Also, consult the posters on display in Watson and Dana.

Introduction

The introduction should explain why the work was done. What were the objectives of the research? How does the research help to fill a hole in our knowledge? The introduction should include a clear statement of the problem or question to be addressed in the experiment. It is always helpful to put this question into some context by stating why this question needs to be answered or why you found this question to be particularly interesting. Any background material that is particularly relevant to the question should be included in this section.

Methods

The methods section tells how the work was done. It should NOT be a simple list of the materials used. What procedures were followed? What research materials were used: the organism, special chemicals, instruments? In some of the experiments you will be doing, many of the procedures are given in great detail in the handouts. It is not necessary to retype these verbatim, but rather summarize the critical steps. The most important feature of this section should be to include enough detail in your description of how your experiment was set up and run so that anyone reading the methods could repeat your experiment. Do not write your methods section as a step-by-step protocol. Write it as descriptive summary of your lab procedures in paragraph form. Include critical information such as the concentration of the reagents you used. Do not include superfluous information that does not affect the outcome of your study (such as what well B2 or A11 contained).

Results

The "Results" section explains in words what you found, the data that you generated, explained succinctly in the body of the report and presented in detail as tables or graphs. The results section should be written so that any college student could read the text to learn what you have done. The text should give the reader a clear idea of the major trends in your data. A reader should have enough information so that s/he could draw the figures (generally) based on your written description of your data in the results section. For example, you might use a paragraph to explain what is seen on a particular graph; "When we soaked the enzyme in sulfuric acid, we observed no change in absorbance (Table 1)" Do not make the common mistake of writing, "We performed the experiment, see figures 1-4." That is too brief and does not describe what you have done or the results you obtained. When stating your results in the body of the text, refer to your graphs and tables. Do not attempt to discuss the interpretation of your data in the results section - explanations should be included in the discussion section. Each table and figure should be numbered sequentially for easy reference in the text, and all figures must have a brief description called a legend, which provides the reader enough information to know what you did to produce the data (even without reading the rest of your manuscript).

Figures & Tables

Data that have been collected need to be presented clearly and succinctly. As a result, two forms of presentation are most commonly used in scientific papers: figures and tables. Which method to use depends somewhat on the data, but in general anything that can be displayed pictorially (*e.g.,* a graph or diagram) is usually more desirable than a table, because the reader can immediately see the trends in the data. In the paper itself, diagrams, photographs, and graphs are all referred to as "Figures", and are numbered sequentially in the order of presentation (Figure 1, Figure 2, *etc.)*. Tables also are numbered sequentially in order of presentation. Although figures and tables often are placed directly into the middle of scientific papers, you may include figures and tables within the text of your report or at the end of your report.

Graphs

Graphs can be made using a graphing program such as Excel. Remember to label each axis, including units of measurement, and clearly identify the data you are displaying (*e.g.,* label each line in a graph). In addition, every graph must have a short description (legend) below it to tell

the reader some basic information about that data and the way it was obtained. The legend starts with the figure number, followed by a one-sentence title. The text of the legend should be a one short paragraph (see Figure 1 below). Notice how the axes are labeled, the figure is numbered and titled (bold font). A good figure is very simple, clear, and the data are obvious (avoid the temptation to add gridlines, 3D effects, shadows, backgrounds, *etc*. Such "chartjunk" distracts your readers from the central message of your data. The figure legend should be sufficient to tell the reader how the experiment was performed and all relevant details. You can look at any scientific paper or your textbook for examples of good figure legends.

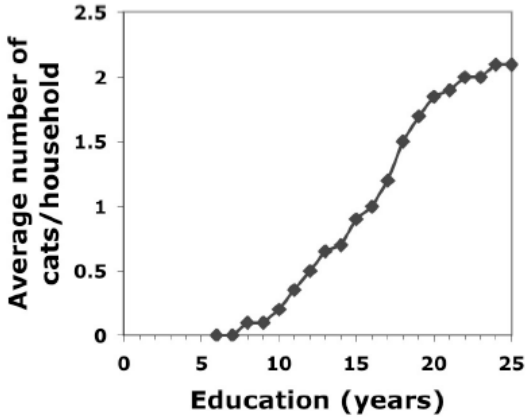

Figure 1. Cat ownership is directly related to educational level. 156 Davidson, NC adult residents were surveyed to determine their education level and the number of cats in the household.

Tables

Tables should be made using the same principles outlined for graphs, though the format is different. Tables can be created with Word or Excel. Tables are numbered, but this number usually appears at the top of the table. The title usually follows the table number:

Table 2. Number of pet cats and education levels for Davidson, NC residents

Subject's Initials	Years of Formal Education	# of pet cats
AN	5	0
CD	12	1
CJL	22	2
CGM	9	1
ABH	7	0

Tables generally do not contain legends. Often, though, footnotes are included under a table to provide explanatory information. Of course, all column headings should be clearly labeled to describe the data listed below them. When preparing your data for a presentation, think about the most effective way of showing your data to the audience.

Some information can be conveyed most effectively in a table. Other information can be conveyed most effectively in a figure. If you do decide to use a figure, then consider what type of

figure will be most effective. In general figures are more effective than tables. When creating graphs you should also think carefully about what type of graph (X-Y, bar, pie, *etc*.) best conveys your results. Always make your figures and tables as simple and clear as possible. Do not make your reader work hard to understand your point.

Discussion

The "Discussion" section typically includes your appraisal of what your research means, including its success in meeting the objectives stated in the introduction, and its significance in advancing your knowledge of the subject. This section also is the place to explain discrepancies or difficulties with experiments, as well as suggestions for future work. For example, if you had known initially what you know now, how might you have changed your experiments? Most importantly, the Discussion provides an opportunity to compare your results with those of others. What previous information exists that is relevant to your research? Do your results support or supplement that information? Once again, when providing your interpretation of the data, direct the reader to specific tables and graphs to prove your point.

References

Finally, it is important to place your work in perspective with the published work of other scientists - references are an important component of any report. Scientific journals usually require specific reference formats. In the text, cite this way (Darwin, 2012). For more information on citing references and academic integrity please consult the biology department's statement on plagiarism at: www.bio.davidson.edu/dept/plagiarism.html.

Interesting factoid about lab reports: If you are under the impression that the research you do is unimportant, then take a lesson from Emily Rosa. Emily published her research results in *JAMA - the Journal of the American Medical Association*. She conducted her research while in the fourth grade! She was curious whether there was any validity to a new form of alternative medical therapy called "touch therapy". She and her mom, a nurse, conducted an experiment that Emily designed. The end result demonstrated that touch therapy was not able to discern as much information as the practitioners claimed. (*JAMA*. 279:1005-10).