HOW TO WRITE LAB REPORTS & SCIENTIFIC PAPERS

P. K. Mendez 2012 (Modified from M. Cover, P. Mendez, Bio1B GSIs, and from Union College, New York: How to Write Lab Reports: http://www.union.edu/PUBLIC/BIODEPT/ResearchReports.html)

LAB REPORT OVERVIEW

The formal lab report is similar to a research report. It should be written as if you were going to submit it to a scientific journal for publication. Therefore, it should follow a very precise format and should be written for a general audience. Assume the reader is familiar with basic biological concepts but does not know anything about the specific lab you have done. The report should focus on three things: the question you are asking, your prediction(s) based on the background information available, and the answer you found by evaluating the evidence gathered in your investigation. All parts of the report should serve to clarify, add to, evaluate, and explain the question and answer addressed by your report. The lab report is as long as it needs to be to convey all of the information, but should be as concise and as well-edited as possible.

GENERAL REQUIREMENTS

_____ Double-spaced in 12-point, Times New Roman (or similar font), with 1 inch (2.5 cm) margins.
_____ Reports should be free from typographical, grammatical, and spelling errors.
_____ Group member names, lab group, and section number must appear with the title information.
_____ Lab reports should be proofread by all group members before they are turned in. All group members must have seen the final copy of the paper before turning it in.
_____ A group contribution sheet must be attached.
_____ Turn in a hard copy and an electronic version (emailed to your instructor and cc all group members).

PARTS OF A SCIENTIFIC PAPER

Scientific papers are made up of three sections, (1) the header and indexing information, (2) the body of the paper, and (3) references.

HEADER AND INDEXING INFORMATION

The header and indexing information is used to let readers know right away what your paper is about and who contributed to the paper. It is usually composed of three main parts: (1) Title and authors, (2) Abstract, and (3) Keywords.

First, you need **a title and identifying information**. This can be bolded or larger font size. It can be centered or not. Because it's at the top of the page and is the first thing the reader sees, a cover page is not needed (please don't make one). You should have (a) the title of the lab report, (b) the people who worked on the report (alphabetize for our lab), (c) the date of the report, and (d) the class, lab section, and lab group (if you have a cool name).

For example:

Lab reports rule as a scientific communication vehicle
Sarah Ismail and Patina Mendez
September 13, 2012, Bio 1B Section 480, Group Old-skool

Second, you need to have an **abstract**. *Abstracts provide a brief synopsis of your goals, methods, and major findings.* The abstract is a short summary (1 paragraph, limited to 200 words) of the experiment or study. If someone read your abstract, they would have a good idea of what your paper is about, how you did it, what you found, and what implications it may have. A good way to write an abstract is to try to summarize the main point from each of the five main sections of your paper (1-4 below) into one to two sentences each. Abstracts are **usually the last thing you write**, because by then, you know what the paper is about and what you did. They usually **do not include any citations**. Cover, in the following order:

- Topic of study and its significance.
- Your specific system and the question you set out to answer.
- Your hypotheses or predictions about outcomes of the experiments.
- The general methods and statistical tests used to collect and analyze your data.
- Your major findings (including number values of interest, if applicable).
- How your findings support or refute your hypotheses.

Finally, a list of **keywords** is included for when the paper is indexed for literatures searches for a system such as BIOSIS or Web of Science. Pick five words that your paper is about that are not in the title, but relate to specifics of the organism you studied, or broader theoretical concepts. For example, if the lab report was on the life history of flying fishes, your keywords section might look like:

Keywords: Exocoetidae, foraging behavior, aerial fishes, predator-prey relationships, mating

BODY OF THE PAPER

The body of the paper is made up of the following sections: (1) Introduction, (2) Methods, (3) Results, and (4) Discussion. Each section should begin with a heading. Sub-headings can be used for different experiments within the methods or results sections.

INTRODUCTION – What did we study?

In this section, you introduce your experiment and answer the question "**What did we study**?" The introduction is usually 3-4 paragraphs but can be longer depending on the subject and the amount of literature that you are reviewing, try and keep it 3-4 though.

The first part of the introduction should **set the context for your experiment by briefly providing background information**. You should present what information is known from previous studies, and then state what additional information your experiment may provide. Be sure to give proper citations when you state facts or ideas from outside sources (see Literature Cited section for more). For example, "The larch is an evergreen that loses its leaves in the fall (Jones, 1921)." Within each paragraph, start with a strong topic sentence as a general statement and become more specific as the paragraph progresses.

In the last paragraph of the introduction, you should **state the objectives, hypotheses**, or particular **questions you investigated**. State what you did in a general way, e.g., "In this study, we investigated the effect of obesity on heart rate by comparing heart rates of normal and obese individuals after a timed stair-climbing activity," or "We investigated two populations of flying fishes to determine (1) the life history, (2) mating behaviors…" but do not give away the specific details. These details belong in the Methods or Results sections. You should focus on identifying a hypothesis and making predictions for these lab reports.

METHODS – How did we study the problem?

> In this section you provide specific information on what experiments you did and how they were done. The methods section answers the question, **"How did we study the problem?"** This section is sometimes also called "Materials and Methods."

The purpose of this section is to allow other experimenters to duplicate the methods you used, so it should be **detailed enough so that someone else could read your report and repeat the experiment** using only minimal additional reference material. Each technique should be a heading with description after it. If there are relevant references or sources for chemicals, they should be cited here. For specific details that are contained in other literature (e.g., your lab manual), you may refer the reader to the methods described there by using a proper citation; you do not need to reiterate these details in your report. However, if the laboratory procedures were changed, describe these in this section. Sometimes your project is has several experiments. **If that is the case, describe each experiment in separate paragraphs and use subheadings to distinguish the experiments.**

The methods section should also include descriptions of any formulae, calculations, or statistical analysis used later in the report. Be sure to include all of the units of measurement. Always use the metric system. Sometimes it is important to include a drawing or photograph of your setup, but only include this if it's important for reproducing the experiment.

In terms of writing, **the experiment has been completed by the time you write your report, so use past tense** when describing it. Some disciplines use **active voice** and other disciplines use **passive voice**. **Use active voice for Bio 1B lab reports.** Passive voice may sound more "sciency," but active voice allows the authors to more directly take responsibility for the work.

Pollen Tube germination assay (example using **active** voice)
We placed pollen from a dicot flower on a glass microscope slide with 1 drop of 2% sucrose solution, followed by a cover slip. **We incubated the sample** at room temperature, **and inspected it** at 400X power at 15-minute intervals.

Pollen Tube germination assay (example using **passive** voice)
Pollen from a dicot **flower was placed** on a glass microscope slide with 1 drop of 2% sucrose solution. A **cover slip was placed** over the sample, which was incubated at room temperature. At 15-minute intervals the slide **was inspected** at 400X power.

RESULTS – What did we find?

> In this section you report the results of your experiments or study, often accompanied by tables or figures. The results section answers the question, **"What did we find?"**

The results section **always starts with normal paragraph (text)** format, NOT with tables or figures. The content will include: general observations made during the experiments; quantitative results, which may appear in figures and/or tables unless there are only a few numbers that can be mentioned in the text; and results of statistical analyses. Data are reported in 3 ways: (1) text, if there are just a few numbers to report; (2) figures, such as a graph, picture, map, or diagram; or (3) tables, which contain only rows and columns of numbers or names.

It usually makes sense to **report the results in a parallel order to the methods**. Keep the sections in the same order as the methods, with the same subheadings. Within each paragraph, cite each table and figure

before they appear, indicate what they show, and summarize the important data. As with all writing the results should be organized into coherent logically organized sentences and paragraphs.

Do NOT discuss the implications of the results in this section, nor attempt to explain why various results occurred. Most of the DETAILS of the results will occur only in figures or tables. Only the important points of each figure and table should be described in paragraph form; don't reiterate the whole figure. For example, "The leaves of manzanita are larger than those of other plants we examined (Figure 1). Similarly, the roots of manzanita are smaller (Table 1)."

Figures and tables

Never include a table or figure that you don't reference in the text. A figure is useless unless you tell the reader when to look at it and why. Each table or figure should be accompanied by a brief **descriptive title** that is detailed enough that the figure can be understood apart from the text. A figure title explains what the figure shows but does not interpret the data (ex: "Figure 1. Cat population versus food supply."). Detail related to the figure would be found in the results section. **Tables / figures must be numbered as independent lists** (you may have both a Fig. 1 and a Table 1). **Tables have a title above, and figure titles are located below**. If it makes it easier to format the paper, you can put all of the figures at the end of the paper, with all of the tables together in order and all of the figures together in order.

DISCUSSION – What do the findings mean?

> The discussion is the final part of your paper where you get to answer the question, "**What do the findings mean**?" It is usually the most important part of your paper. Although the results section explains detail of each figure or table, the discussion section interprets the entire work as a whole. In a research publication this section is used to place your work in the context of previously published work and discuss the significance. It is also the section where possible future experiments are discussed.

The discussion is your chance to be original, cleverly interpret the results you obtained, and draw general conclusions. Information in the discussion should start with your specific results and move toward the more general themes or theory. Begin the discussion by briefly stating the major conclusions from the results. Explain what the results mean. **Discuss whether the results SUPPORT or do NOT support your original hypothesis(es)**. Be careful not to extrapolate too liberally from your data, i.e., don't tell stories! If your findings are inconclusive, do not try to stretch them to unreasonable ends. Sometimes in this section you also include possible sources of experimental error and what effect you would expect these to have on your results (if you strongly believe in your results, don't undermine your findings, but instead explain why this error is unlikely or not possible).

In next paragraph(s) expand your discussion of these results. You might wish to compare them to results from other studies, which you should cite properly. As the discussion continues it is important to offer some original ideas and interpretations. For example, discuss the implications or your results for the biology of the organism(s). For example, why did the behaviors you observe evolve? You may wish to suggest new experiments that would shed further light on the questions raised by your results, or mention if there were any major problems with the study.

Conclusions

In a short paper a conclusion is optional. If your discussion is lengthy it is a good idea to summarize the main points of the study in a conclusion paragraph. For example, you might write, "In conclusion, we found that manzanita is very different from other plants because…"

LITERATURE CITED

You should cite all references that you used in your lab report. Use the *Ecology* journal citation format. **All citations should be listed in alphabetical order by last name**. Only include references you cite in the paper. Make sure to check your paper over closely for the correct format and congruence between the body of your paper and the literature cited. A good guide for the Ecology reference format is: http://csus.libguides.com/ecology . Use the tabs for In-text citations and Literature Cited/Bibliography.

Journal Articles:
Last Name, First and middle initials. Year. Title of Article. *Journal Name* Volume: page numbers.

> Gabriel, W. L., M. P. Sissenwine, and W. J. Overholtz. 1989. Analysis of spawning stack biomass per recruit: an example for Georges Bank haddock. *N. Am. J. Fish. Mgmt.* Vol. 9: 383-391.

Books:
Last Name, First and middle initials. Year. Title. Publisher, City, State (or Country).

> Hillborn, R. and C, J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics & uncertainty. Chapman and Hall, London.

Specific selection from a book
Last Name, First and middle initials. Year. Title of Selection. In: Last Name, First and middle initials (editors). Title of Book. Publisher, City, State (or Country), pages.

> Mock, D.W. 1997. Infanticide, siblicide and avian nestling mortality. In: Hausfater, G. and Hardy, S.B. (eds). Infanticide: comparative and evolutionary perspectives. Academic Press, New York, pp 3-30.

In the paper, you can cite in-text in two ways:

1. Horses evolved a long time ago (MacFadden 2005). ← The more preferred way.
2. According to MacFadden (2005), horses evolved a long time ago. ← Ok.

If there are more than three authors, give only the first author in the in-text citation, followed by et al. (The phrase e*t al.* means "and others".) You may cite more than one author for an idea, if you are drawing from several papers. Multiple sources should be listed chronologically. Ex: (Gabriel *et al.* 1989, Hillborn and Walters 1992, and Mock 1997).

Every idea, method, or piece of information included in your report that is not your own should have a reference associated with it (unless it is very common knowledge)!! **Not properly giving credit for the work of others is considered to be plagiarism and will result in reporting to the university.**

You should use primary literature as references. This literature consists of papers describing actual experiments and results. Review articles are also acceptable sources of information, if published in a peer-reviewed source.

A NOTE ABOUT PLAGIARISM

Plagarism, or using the words of others without attributing authorship, is a serious academic offense. Please read over the information at http://www.plagiarism.org for examples and clarification on intentional and accidental plagiarism. Plagiarism offenses in Bio1b may result in failing the class and possible expulsion from UC Berkeley.

LAB REPORT CHECKLIST

General:

_____ 12 pt serf font.
_____ Double-spaced.
_____ Typo free and edited so that the lab report reads as if one person wrote it.
_____ Title descriptive and concise.
_____ Author info (date, group etc.) complete.
_____ Group contribution form, all members have read the lab report before it is turned in.
_____ Hard copy and electronic version.
_____ No piece of the work is plagiarized (see www.plagiarism.org).

Abstract:

_____ 200 words or fewer.
_____ Contains purpose of experiment.
_____ **Contains hypotheses or predictions about outcome of the experiments.**
_____ Contains brief description of methods.
_____ **Contains major findings.**
_____ Contains conclusions.
_____ Keywords are listed below the abstract.

Introduction:

_____ Contains background information from the literature (primary references).
_____ Citation format is correct.
_____ Citations are paraphrased. Direct quotations are not used.
_____ **Objectives of experiment (or hypotheses) are clearly stated.**

Methods:

_____ Contains all relevant information to enable the reader to repeat the experiment.
_____ Written in past tense and active voice.
_____ No preview of how the data will be organized or interpreted.
_____ Subheadings are used when necessary.
_____ Diagram of setup (optional).

Results:

_____ **The results are described in words**.
_____ Reference is made to each table / figure.
_____ **Figures and tables are present.**
_____ Figure / table titles are informative and can be understood apart from the text.
_____ Figure titles are below the figure and table titles are above the table.
_____ Figure axes (with units), table columns, data sets etc. are clearly labeled.
_____ Results contain *no analysis.*
_____ Subheadings (if used) are parallel to methods section.

Discussion:

_____ Results are briefly summarized.
_____ **Results are interpreted in relation to hypothesis(es).**
_____ Explanations for results are given; implications are considered.
_____ Errors and inconsistencies are pointed out and dealt with.
_____ Limitations to the experimental design, improvements to the study or other types of data that may elucidate the questions are addressed.

Literature Cited:

_____ Citations are properly formatted.
_____ References consist mostly of primary journal articles, not textbooks or internet sources.
_____ All references have been cited in the text. All citations in the text have been included in the Literature Cited section.

Items in bold represent critical portions of the lab report that weigh more heavily than others.