

Guide for the Written Portion of Laboratory Work

Acknowledge that there is no strict regimen to follow when writing a research paper, but the information below details one recommended format that may be used.

This lab manual is adapted from the General Ecology Laboratory Manual for PCB 4043 prepared by Schuur et al. (2011), STEM Research Handbook by Darci Hartland (2011), and the University of Florida's Student Science Training Program Academic Manual.

Laboratory Notebook

- Having a laboratory notebook is absolutely necessary when working in the lab—it assures you to stay organized, keep track of all your procedures, and can be used as definitive evidence for the data/results you received.
- In general, each page should include your name and the date.
- A notebook with carbon copies is especially useful as you will always have two copies of your pages, and your notebook does not have to leave the lab and risk being lost.

Taking Notes

- Throughout your research, you will be writing many things in your laboratory notebook, including but not limited to data, observations, background information, procedures, results, purpose, and references.
- You should always use a pen unless otherwise instructed.
- Keep in mind that the more information you include in your notes/laboratory notebook, the easier it will be to recall information later and hence write a research paper or give an oral presentation. This is especially useful as research is generally quite advanced and technical; furthermore, do not rely on solely your memory.
- If you make an error or do not use an additional space at the bottom of a page, draw an X and initial next to the X. This assures that the researcher did any of the changes made to the laboratory notebook.

Formatting

- This is variable and it is recommended you ask your professor.
- In general, a research paper written using the following:
 - Times New Roman font
 - 12 point font
 - Text aligned left
 - 1-inch margins
 - Double spaced

Paper Assembly

- Altogether, your research paper should follow this general structure:
 - Title page
 - Abstract
 - Introduction

- Methods
- Results
- Discussion/Conclusion
- Acknowledgements
- Literature Cited
- Tables
- Figures
- Begin each section with its respective section name
- Use a header, including the page number, at the top right corner of each page except for the title page
- Under each section of the paper, subsections may be used to help format and appropriately organize your paper. These subsections should be used throughout the paper, so the readers can follow specific portions of your research. For example, if one of your subsections in Methods is “Protein Expression,” you should also include a subsection in your results called “Protein Expression.”

Title Page

- This should generally include the following:
 - Title of your project
 - Your name
 - Your email (optional but often recommended)
 - High school or college you attend
 - Professor you work with
 - Name of the lab in which you perform your research
 - Name of institution that you performed your research
 - Date you completed your research
- The title of your project should be brief and hint at your research area.
- In general, use common names in lieu of scientific names for simplicity. If necessary, you may include the scientific name in parentheses, but make sure you use the proper conventions.

Abstract

- This basically summarizes your research and provides the most important points.
- The abstract is extremely important as it can make or break your research paper—the readers normally decide if they will read the research paper solely based on the abstract.
- You will have two separate abstracts that are formatted differently: paper abstract and standalone abstract.
 - Paper abstract:
 - Included directly in the research paper and follows the same format of the rest of the paper
 - This will be placed after the title page but before the introduction
 - Standalone abstract:
 - A separate document intended for use when the detailed research paper is not necessary
 - Single spaced

- Includes name, high school/college, research advisor/professor, research site, title, body, and keywords. In contrast, only the body will be included in the paper abstract.
- The abstract should *briefly* state the experimental hypothesis, purpose/research goal, most important procedures, and a discussion of results and conclusions.
- This should be written last and not exceed approximately 250 words.
- Also, below the abstract, you should include a list of five to seven keywords (or two to three short phrases) that help researchers find certain topics in a literature search. These keywords should be unique and specific to your research paper.

Introduction

- Since research can be very advanced, an introduction is absolutely essential to a research paper and intended to inform the readers about your research so they can fully comprehend your paper.
- In this, you should detail the significance and purpose of this research, making sure to retrieve your information from scholarly sources. You should cite these sources in both the literature cited section and as parenthetical citations in the introduction.
- The introduction should begin with a broad overview of the field and then narrow the focus to your specific research project.
- In the introduction, consider answering the following questions:
 - Why is this topic important to research?
 - What is already known about this research?
 - What have past studies found regarding your research field?
 - What does one have to know in order to fully understand your research paper?
- When providing scientific background information, acknowledge that the readers will most likely be professors who have experience in your field of research. For example, there is no need to explain how a Western Blot works, because you can assume the reader knows this information. On the other hand, a specific sequence of DNA that is not commonly known should be explained.
- After reading the introduction, the reader should know your research question, hypothesis, and purpose of your study.
- Keep in mind that not all research projects are hypothesis driven, so you must determine whether or not your project needs a hypothesis. In addition, some projects have multiple hypotheses, so once again, include what is necessary for your specific research paper.
- The introduction should end with the purpose and hypothesis of the research.
- As a researcher in a laboratory, plagiarism can be detrimental to both you and your professor. It is extremely unprofessional and immoral. Do not, in any situation, directly copy another person's intellectual property. It is still considered plagiarism if you change one or two of the words. In order to avoid this, always use proper citations.

Methods

- Always write in full paragraphs unless otherwise instructed.
- Your methods will always be in the past tense.
- Avoid the use of the word "I." This may force you to use passive voice, which is acceptable in most fields.

- You may want to look at the method sections in common scientific journals in your field in order to see the conventions of your field.
- Subsections are useful in this section, but be sure to use these same subsections in other areas.
- Be sure to include statistical tests.
- Use descriptions that are comprehensible to the readers, not just the researcher. For example, say “10mL solution was exposed to the light for 30 minutes” in lieu of “Sample 1 was exposed to test A lighting.” This allows for ease in both reading and reproduction of the experiment.
- Be specific but not too specific. For example, it is not necessary to say the following when adding 5mL of buffer to a solution: “Grab micropipette, position hand, compress to first notch, insert into sample, slowly release, carefully move micropipette with fluid...” Instead, simply say, “Add 5mL of buffer to the solution.”
- If necessary, use parenthetical citation to cite the source in which you found the procedures.
- You may include a photograph of your experiment apparatus/setup in the Figures section, but refer to it accordingly. Do not include the photograph in the methods section, but instead say “...as seen in Figure 1.” The readers can then move to the figure section if they would like to see the image, and the methods will be more fluid and joint.

Results

- As with the methods, write in full and complete paragraphs.
- It is important that there are results for each method, hence using the same subsections is useful for organization. A reader should be able to put you methods and results side-by-side and see the results.
- The results are written in the past tense.
- If you do not have all your data, you may state the anticipated data and dates.
- Acknowledge the difference between the results and discussion/conclusion sections. In the results, you are only reporting the results. You will state the trends, statistical results, qualitative and quantitative observations, etc.
- Since you are describing the data, it is especially useful to refer to the Tables section. Include the data tables you constructed in that section. Similar to the figures included, you will say things along the lines of say “...as seen in Table 1.” These tables should separate the raw data from the statistical results.
- You will not synthesize your data and explain it using past literature in this section; you will simply state the facts.
- Be specific but not too specific. Describe the overall trends in your data, but do not list every single piece of raw data. If you do not have a large quantity of averaged/manipulated, you may include this.
- Make sure to include all units.
- When detailing the results of a statistical test, you may include the specifics of the test in parentheses. For example, “On average, the black Labradors had a higher incidence of heart disease than chocolate Labradors (two sample t-test, $t=5.78$, 33 df, $p<.05$; Figure 1).” It is not necessary to include paragraphs of information detailing each value in the statistical test.

Discussion/Conclusion

- Clearly state whether or not the data aligns with the proposed hypothesis. You must further this point by explaining why or why not this result was received.
- If possible, use the active voice but do not overuse the word “I.”
- Here you will take the results and explain them using your scientific knowledge and literature. Interpret the results and explain why you received the respective result.
- Detail the implications of your finding and how your results contribute to the scientific community as a whole.
- Detail the future of this project, specifically the next steps of this projects if it is being furthered.
- Discuss any possible sources of error, making sure to distinguish between systematic and random error. Keep in mind that random error may be reduced with a larger sample size, so this may be a way to better your experiment in the future.
- Discuss any anomalies in your data and explain possible causes.
- When referring or using information found in literature, be sure to include a parenthetical citation. It is highly likely that you will use multiple parenthetical citations in this section.
- Instead of restating the results, explain them.
- Here is a distinction between the results ad discussion, provided by the University of Florida’s Student Science Training Program:

“**Results:** Soaking seeds had an effect on the germination rate of lima beans (Fig 1). The germination rate of seeds soaked in room temperature water for three days was the highest (92%) which was twice the germination rate of seeds soaked for 1 day; and three times that of the seeds soaked for 5 days and the control group which were not soaked.

Discussion: The results of the lima bean germination experiment (Fig. 1) suggest that the optimal duration for soaking seeds is 3 days. This group showed the highest cumulative germination (92%), with longer (5 d) or shorter (1 d) exposures resulting in fewer seeds germinating. *From here the author may talk about biologically why the three day treatment was the optimal soaking duration and/or how this experiment has applications beyond research, such as in farming. New hypothesis and further work may also be discussed.*”

Acknowledgements

- In this section, include one to three sentences thanking the people who have helped you in your research endeavors. This generally includes the people who helped you in the lab, your professor, reviewed your research paper, provided funding, helped you get the research position, etc.
- Ex. “I would like to appreciatively extend my gratitude to the various people who have assisted me in completing this project and acted as a backbone for current and future endeavors:
_____.”

Literature Cited

- Begin this on a new page
- You may use either RefWorks or Easy Bib to help with your citations.

You Research

- There are many types of citation formats: MLA, APA, Chicago, etc. There are multitudes of online sources to help correctly cite your sources. Make sure you use them!

Tables

- Here you will include all of your data tables.
- Keep in mind that your experiment may not have data and hence you will not need to include this section.
- Include tables of both quantitative and qualitative data.
- Above each table, you should title it (“Table 1” or something similar) and provide a brief caption describing the data. Once again, include the caption *above* the table.

Figures

- Here you will include all of your data tables.
- Keep in mind that your experiment may not need this section.
- Under each figure, you should title it (“Figure 1” or something similar) and provide a brief caption describing the data. Once again, include the caption *below* the figure.