

Guidelines for Writing a Scientific Paper

Writing an effective scientific paper is not easy. A good rule of thumb is to write as if your paper will be read by a person who knows about the field in general but does not already know what you did. Before you write a scientific paper read some scientific papers that have been written in the format of the paper you plan to use. In addition to the science, pay attention to the writing style and format. (DOUBLE SPACED – PLEASE!!!)

COVER PAGE:

On the cover page, list the title of your specific investigation (not just the lab name from the manual!). A general rule of thumb (but not always applicable is somewhat like the following example: "**The Effect of <your independent variable> on your <dependent variable>**"). Beneath this is traditionally the abstract (more on this below). Names of group members, class period, instructor, and date submitted should be at the bottom right of this page.

ABSTRACT:

An abstract is a succinct (one paragraph) summary of the entire paper. The abstract should briefly describe the question posed in the paper, the abbreviated methods used to answer this question, the results obtained, and the conclusions. It should be possible to determine the major points of a paper by reading the abstract. Although it is located at the beginning of the paper, it is *easiest* to write the abstract after the paper is completed.

INTRODUCTION:

This section of your lab report provides the conceptual basis and/or theoretical background of your experiment. Design this section of your lab report using three (3) 'sections':

1. **Identify and in detail, explain** the question investigated – along with the theory/principle/concept illustrated*. Use in-text citations (properly formatted – see citation section) when quoting the textbook or various other resources.
2. **Describe** the basic components of the experiment. This subsection should **just** be a short paragraph that specifically states the independent, dependent, and 'controlled' variables.
3. **Clearly identify your hypothesis and explain how this design will test it—that is, what you expect will happen and what you expect your specific data will be from the investigation.**

This introduction section will take some research. Do not try to do this off the top of your head!

METHODOLOGY

The Methodology section should succinctly describe what was actually done. It should include description of the techniques used so someone could figure out what experiments were actually done. The details of a published protocol do not need to be reproduced in the text but an appropriate reference should be cited – e.g., simply indicate "were done as described by Hughes et al. (4)". Any changes from the published protocol should be described. It is not appropriate to indicate volumes of solutions added – instead indicate the relevant information about the experiment such as final concentrations used, etc. **Do not just copy the steps from the manual!** This should be written in paragraph form, third person, past-tense.

RESULTS – OPENING STATEMENT

Begin this section with an opening sentence that tells the reader the generalized results were. **Write the opening sentence in bold font for emphasis.** Then, follow this with a paragraph that indicates what the results were – use the data! Any results that include multiple data points that are critical for the reader to evaluate the experiment should be shown in tables or figures (see next section). However, the results should be summarized in accompanying text. When referring to a particular table or figure, they should be capitalized (e.g., Table 1, Figure 6, etc.). The text of the Results section should be succinct but should provide the reader with a summary of the results of each table or figure.

Not all results deserve a separate table or figure. As a rule of thumb, if there are only a few numerical results or a simple conclusion describe the results in the text instead of in a table or figure.

Your paper should focus on what worked, not things that did not work (unless they didn't work for reasons that are interesting and provide biological insights).

RESULTS – TABLES AND FIGURES

All tables and figures should be put into a contextual framework in the corresponding text. (A table of bacterial strains used should be mentioned in the Methodology section, a table of data collected should be summarized in the Results section, a figure showing a biosynthetic pathway to further explain a concept should be described in the Introduction or Discussion section, etc.) Tables and figures should present information in a format that is easily evaluated by the reader. **A good rule of thumb is that it should be possible to figure out the meaning of a Table or Figure without referring to the text.**

Tables and figures should typically summarize results, not present large amounts of raw data. When possible, the results should provide some way of evaluating the reproducibility or statistical significance of any numbers presented.

- Tables should be sequentially numbered. Each table should have a caption (shown above the table) that describes the point of the table. For example, "Table 1: Bacterial strains and plasmids used in this study." If necessary to interpret the table, specific descriptions about what a result represents or how the results were obtained can be described in a legend below the table.
- Figures should be sequentially numbered. Each figure should have a caption (shown below the table) that describes the point of the table. For example, "Figure 1. Isolation of *MudJ* insertion mutants." If necessary to interpret the figure, specific descriptions about what a result represents or how the results were obtained can be described immediately following the title.

Tables and figures should be integrated into the paper. Make sure that there is not a page break in the middle of a table or figure. Do not wrap text around the outside of tables and figures – if the results are important enough to show as a table or figure they should stand out on the page, not be buried in text. Formatting counts! Make this section easy to read!

DISCUSSION - CONCLUSIONS

In this section of your lab report, **you will give your interpretations of the data**. You must open with a statement that either shows that the data supported or refuted your hypothesis. **Either way, explain the significance of your data**. Do not simply restate the results — explain your conclusions and interpretations of the Results section. How did your results compare with the expected results? What further questions/predictions can be gleaned from the results? In this section, “dazzle us” with your knowledge of the concept and why the results were what they were. This is the goal of each experiment — to see if your hypothesis stands up to testing and to possibly prompt new questions!

ERROR ANALYSIS – ERROR ANALYSIS

Finally, you will have to provide **one and only one** actual (or possible) source of error that did (or might have) influence the results. This is more than just stating “We could have measured the sample wrong”. To receive full credit for this, you must do the following three things:

1. List actual (or possible) source of errors that did (or would have) altered the results.
2. Describe the effect on the results caused (or would have) by each possible error.
3. Explain how you could correct the error.

CITATIONS/REFERENCES:

Whenever you are using information from other sources, you need to properly cite your work. Also, when using these external sources, it is not a cut and paste and be done with it method. You must write out the findings in your own words and then properly cite it. If this does not occur, it is called plagiarism—and you will lose credit for the **entire** lab—or worse!

Look at the resources at the end of this manual and check here for more details on this... <http://library.duke.edu/research/citing/> How do you properly cite work? Once you refer to one of your references, it is common to cite in text as you use the information. I recommend using numbers (or author names) corresponding to sources listed in the citation section.

Example: Blah blah blah blah blah blah **(Goldberg)** blah blah blah. Blah blah blah blah blah blah **(DeMarco)** blah blah blah...

Example: Blah blah blah blah blah blah **(1)** blah blah blah. Blah blah blah blah blah blah **(2)** blah blah blah...

When using online documents here is the minimal citation required is listed below. Oh, and **USING WIKIPEDIA IS NOT AN ACCEPTABLE SOURCE OF INFORMATION!**

Author's name (last name first). "Document title." Date of Internet publication.
Date of access <URL>.

ex:

- Landsburg, Steven E. "Who Shall Inherit the Earth?" *Slate* 1 May 1997. 1 Oct. 1999
<<http://www.slate.com/Economics/97-05-01/Economics.asp>>.
- Mitchell, Jason P. "PMLA Letter." Homepage. 10 May 1997. 1 Nov. 1999
<<http://sunset.backbone.olemiss.edu/~jmitchel/pmla.htm>>.

FORMAT/PRESENTATION:

Your lab report needs to be composed in a grammatically correct fashion. Spelling and grammar do count! Also, cut to the chase. **Except for in the discussion section, be brief and concise.** There is not a point value for word count! Always spellcheck your paper and carefully proofread your paper before submission. In addition to checking for errors and typos, read your paper to yourself as if you were reading it out loud to ensure that the wording and sentence construction is not clumsy. Here are a few hints...

Flow – Readers interpret prose more easily when it flows smoothly, from background to rationale to conclusion. Don't force the reader to figure out your logic – clearly state the rationale. In addition, it is much easier on the reader if you explicitly state the logic behind any transitions from one idea to another.

Abbreviations – Use standard abbreviations (hr, min, sec, etc) instead of writing complete words. Some common abbreviations that do not require definition are shown on the attached table.

Define all other abbreviations the first time they are used, then subsequently use the abbreviation [e.g. Ampicillin resistant (Amp^R)]. As a general rule, do not use an abbreviation unless a term is used at least three times in the manuscript. With two exceptions (the degree symbol and percent symbol), a space should be left between numbers and the accompanying unit. In general, abbreviations should not be written in the plural form (e.g. 1 ml or 5 ml, not mls).

Past, present, and future tense – Results described in your paper should be described in past tense (you've done these experiments, but your results are not yet accepted "facts"). Results from published papers should be described in the present tense (based upon the assumption that published results are "facts"). Only experiments that you plan to do in the future should be described in the future tense.

Third vs. first person – It is OK to use first person in scientific writing, but it should be used sparingly – reserve the use of first person for things that you want to emphasize that "you" uniquely did (i.e. not things that many others have done as well). Most text should be written in the third person to avoid sounding like an autobiographical account penned by a narcissistic author. However, it is better to say "It is possible to .." than to say "One could ...". Writing that uses the impersonal pronoun "one" often seems noncommittal and dry.

In addition, inanimate objects (like genes, proteins, etc) should be described in third person, not with anthropomorphic or possessive terms (e.g., instead of saying "its *ori* site", say "the chromosomal *ori* site").

Empty phrases – Avoid using phrases that do not contribute to understanding. For example, the following phrases could be shortened (or completely deleted) without altering the meaning of a sentence: "the fact that ..." (delete); "In order to ..." (shorten to simply "To ..."). Likewise, the title of a table of results does not benefit from the preface "Results of ...". **In short, don't use more words than you need to make your point.**

Specify – If several expressions modify the same word, they should be arranged so that it is explicit which word they modify. It is common to use a pronoun such as “it” or “they” to refer to a concept from the previous sentence. This is OK as long as there is only one concept that “it” or “they” means. However, if there are more than one concepts it is easy for the reader to get confused about what the pronoun is meant to specify (even if you know which one you mean). It is better to error on the side of redundancy by repeating the concept in subsequent sentences, than to take the chance of confusing the reader. Don’t make the reader guess what you mean.

Parentheses – Avoid double parentheses. For example, “Three gene products catalyze reactions in the pathway for proline biosynthesis (Figure 1) (3)” could be reworded to say “Figure 1 shows the three reactions of the pathway for proline biosynthesis (3).”

SOME USEFUL RESOURCES:

- Alley, M. 1996. The craft of scientific writing, 3rd edition. Prentice Hall, NJ. [and accompanying web site: [<http://filebox.vt.edu/eng/mech/writing/>]]
- Day, R. 1998. How to write and publish a scientific paper, 5th edition. Orynx Press.
- Day, R. 1995. Scientific English: A guide for scientists and other professionals, 2nd edition. Orynx Press.
- Goben, G., and J. Swan. 1990. The science of scientific writing. Am. Scientist 78: 550-558. [Available online at <http://www.research.att.com/~andreas/sci.html>]
- McMillan, V. 1988. Writing papers in the biological sciences. Bedford Books, NY.
- Strunk, W., and E. B. White. 1979. The elements of style, 3rd edition. MacMillian Publishing Co.
- Word usage in scientific writing [<http://www.ag.iastate.edu/aginfo/checklist.html>]]
- Dangling modifiers
[http://owl.english.purdue.edu/handouts/grammar/g_dangmod.html]]