

Some guidelines for writing lab reports

Reports should be no longer than they need to be to completely describe the work that was done and meaningfully explain the data that was obtained. Remember, your work in the lab is as good or bad as your lab report.

The following is not necessarily a complete guide for report writing, but just some suggestions that I have thought of and written down while reading a variety of students' lab reports.

Abstract

A proper abstract is a concise summary of the paper (or presentation, or book chapter). It is not an introduction. The abstract should include a brief introduction to the experiment, why it is important, how it was carried out, and the important results that were obtained; including important numerical data. The amount of detail given in the abstract will depend on the allowed length.

An abstract needs to stand on its own. In general, references to other work should not be included unless there is a compelling reason to include them. References to figures and tables that may appear in the main body of the paper should not be made. (Figures and tables may be included in extended abstracts, which are usually written for conference proceedings.) If acronyms are used they must be defined the first time they are used. (Acronyms must always be defined the first time they are used unless they refer to commonly known measurement units). However, since the abstract stands alone, acronyms must be defined again in the main body of the paper, even if they have already been defined in the abstract. Do not use an acronym if it is not going to be used again.

Introduction

The introduction is used to tell the reader why you did the experiment. The introduction should include a discussion of the science behind your experiment, and results that others may have attained. Important historical references regarding work related to your experiment should be in this section. If your experiment tested a particular hypothesis or theory, it should be stated in the introduction. The results of your experiment should not be given in the introduction. There are usually no figures or tables in the introduction, unless they are referenced from some other source.

Parts of the introduction may be in the past tense and others in the present tense. If you are discussing a specific experiment or specific work that happened in the past, it should be presented in the past tense or mixed tense. For example, "Smith et al. (2003) found that time of flight mass spectroscopy works better than ion trap mass spectroscopy due to the faster response time." If you are discussing something in general that is not linked to a specific reference, use the present tense. For example, "Isoprene is the most prevalent volatile organic compound emitted by plants." A statement like this may be followed by one or more references if it is not general knowledge in the field.

Experiment

The experiment section tells the reader how you carried out your work. This section should describe in detail: where chemicals were obtained and what quality they were, methods and equipment used, any parameters that were set for these methods or equipment, how

instrumentation was calibrated, how experimental controls were set up, any sampling and analysis protocols that were used, calculations that are not routine, etc. The amount of detail given should not be more than is necessary for the reader to repeat what you have done in the general sense. For instance, if you are describing how calibration solutions were made, it is appropriate to say, “A range of Ca^{2+} calibration solutions from $1.00\mu\text{M}$ to $10.0\mu\text{M}$ were prepared using volumetric glassware by serially diluting the 5.00mM Ca^{2+} stock solution with deionized water.” (We assume here that the 5.00mM Ca^{2+} stock solution has already been discussed.) This amount of detail will allow anyone familiar with wet chemistry to make calibration solutions in the proper range. It would not be appropriate to say, “To make a $10\mu\text{M}$ Ca^{2+} calibration standard, 2.00mL of the 5.00mM Ca^{2+} stock solution was added to a 1000mL volumetric flask using a 2.000 mL volumetric pipet, and then the volumetric flask was diluted to the mark with deionized water.” This statement is wordy and unnecessary. However, if you are discussing a procedure that is new, extremely uncommon, or very sensitive to small changes in the procedure that may alter the outcome of the experiment, then this sort of detail may be appropriate. If some parameter was changed half-way through the experiment (and data is used from both before and after changing the parameter), then it should be mentioned in the experiment section. Why the parameter was changed should appear in the discussion section (a brief comment on why it was changed could be included in the experiment section to avoid confusion). None of your actual data or results should be presented in the experimental section.

Figures may be used in the experimental section if they show how an instrument was set-up or to show visually how an experiment was carried out. A table may be used to demonstrate a sampling protocol in a better way than could be explained in the text. In general, figures and tables should always be used sparingly, and only if they result in a better presentation of information than can be accomplished in the text. Never put a figure or table in your paper unless you refer to it in the text, and specifically discuss the contents of the figure or table in the text. If one of your figures is used to show an equation, use an equation editor to properly present this.

Most of the time, the experimental section will be written in the past tense. Any time you discuss something that was done in your experiment it should be in the past tense. However, if you are writing about something in the general sense, then the present tense should be used. For example, “Mass 67^+ **was** used to monitor isoprene since it **is** the most prevalent mass produced in the electron impact ionization of isoprene.” The first part of the sentence is in the past tense since it refers to the experiment, the second part of the sentence is in the present tense, since it is a general property of electron impact ionization.

Results/Data

The results/data section presents your data to the reader, but does not present an analysis of that data. Since this is sometimes difficult to do, it is common to combine the results section with the discussion section. Only show results that are pertinent to your experiment. If you made a mistake during the experiment, do not show the data from the mistake. Only show bad data if that data was used to direct the next step of the experiment. This would be common if your experiment involved method or instrument development. Do not show the same type of data more than once unless there is a good reason to do so. If you are analyzing ten samples with various concentrations of phenols by chromatography there is no reason to present more than one of the chromatograms; in general, they all look the same. A graph of concentration versus sample number, or time, or whatever is appropriate, would be more useful to the reader. Be sure

to always use the appropriate number of significant figures in every number you report, including on the axes of graphs. Also be sure to include units with every number you report in the text, and in figures and tables. If the units require superscripts or subscripts, format these properly. There is no excuse not to when using a modern word processor. Avoid reporting raw data. For example, if you want to show the results of several chromatography analyses in a table, convert the area units to concentration (based on the calibration), or some other useful units before making the table. An exception to this may be if you are reporting the results of repeated standard analyses to demonstrate precision.

Discussion

The discussion section should be used to put your results into the proper context. It is commonly combined with the results section. The results of the experiment should be explained in a meaningful way. This may include: comparing your results with the results of others (in your class or from published work), comparing various results from your own experiment, explaining how your work demonstrates a certain scientific principle, or supports or disagrees with a particular hypothesis or theory, discussing the quality of your data and if the quality of the data is not as good as possible, why, etc. If you want to show the process of making specific calculations, put these in an appendix at the end of the report. Do not go through detailed calculations in the main body of the report; although important equations that are used for making calculations may show up in the experiment section. Detailed calculations should only appear in the main report if the study involves the derivation of the equations. The discussion section of your report should be the most thought out and interesting.

Conclusion

An effective conclusion is used to reflect on the experiment, to suggest improvements for future experimenters who might repeat the work, and to suggest ideas for further studies that the current work has inspired. The intention of the experiment may be repeated (from the introduction) and whether or not the original goals were met can be discussed. Although the major results may be restated in a conclusion, this is not the primary purpose of this section.

Helpful comments on figures and tables

- Only use a figure or table when necessary. Ask yourself if the information in the figure or table can be adequately described in the text alone.
- Label figures and tables separately and in order.
- A caption should be associated with every figure or table. The caption should not rely on the text of the paper, although the reader can be referred to the text for more information.
- Every figure and table included in the paper must be referred to in the text, and must be referred to in order. If the figures and tables are embedded in the text, try to have the referral in the text come before the figure or table appears. Otherwise, it is acceptable for all of the figures and tables to be included (in order) at the end of the text.
- The first time that the figure or table is referred to in the text, the figure or table must be described. Describe what the figure or table is displaying, and then discuss the data in the figure or table. After this, it is ok to make a reference to the figure or table without a specific discussion of the data in the figure or table. Use the present tense when referring to the actual table or figure. For example, "Figure 1 illustrates how the helium carrier gas was used to desorb compounds from the sampling traps."

- Use the correct or at least a reasonable number of significant figures in every number reported (and be consistent).
- Whenever possible, show uncertainty in your data. Use error bars on graphs to show uncertainty in each point, or to show variations from one analysis to the next. Be sure to explain your error bars or uncertainty in the caption.
- Units must be associated with every number reported. This may appear in the column heading for a table, or on the axis label in a graph. For chromatograms it is ok to use 'detector response' for the units of the y-axis, and area units for peak areas, however it is better if area units are converted to the final units used (the same units as the standards).
- Most instrument software allows the user to format how data looks for printing. Spend the time to learn the software and make your data look the way you want it before printing it out.
- The font for all lettering should be the same as in the text whenever possible. Do not use smaller than 10 point font in figures and 12 point in tables.
- All lines and points should show up clearly. This includes axis, trend lines, and data points.
- Use all of your space. There is no reason to have a graph on half a piece of paper if the other half is empty.
- Use enough space to display the data well. Short and wide chromatograms do not do as well as tall ones.

Some unacceptable errors commonly found in lab reports

- Having numerous and blatantly misspelled words.
- Using poor writing structure (not having periods after sentences, missing spaces, etc.).
- Not describing and discussing figures and tables that are included in the report.
- Poor labeling of figures and tables, for example, if multiple figures have the same figure number, or if the incorrect figure is given in the text.
- Being excessively redundant. Never repeat what you have already said in the report; especially word for word. It may be appropriate to restate an idea if it is very important.
- Not reporting units (or incorrect units) and obviously reporting too many significant figures.
- Not using appropriate symbols, sub, and super scripts, and not using an equation editor to display equations.

All of these can easily be avoided by carefully reading your report before handing it in and having some pride in your work.