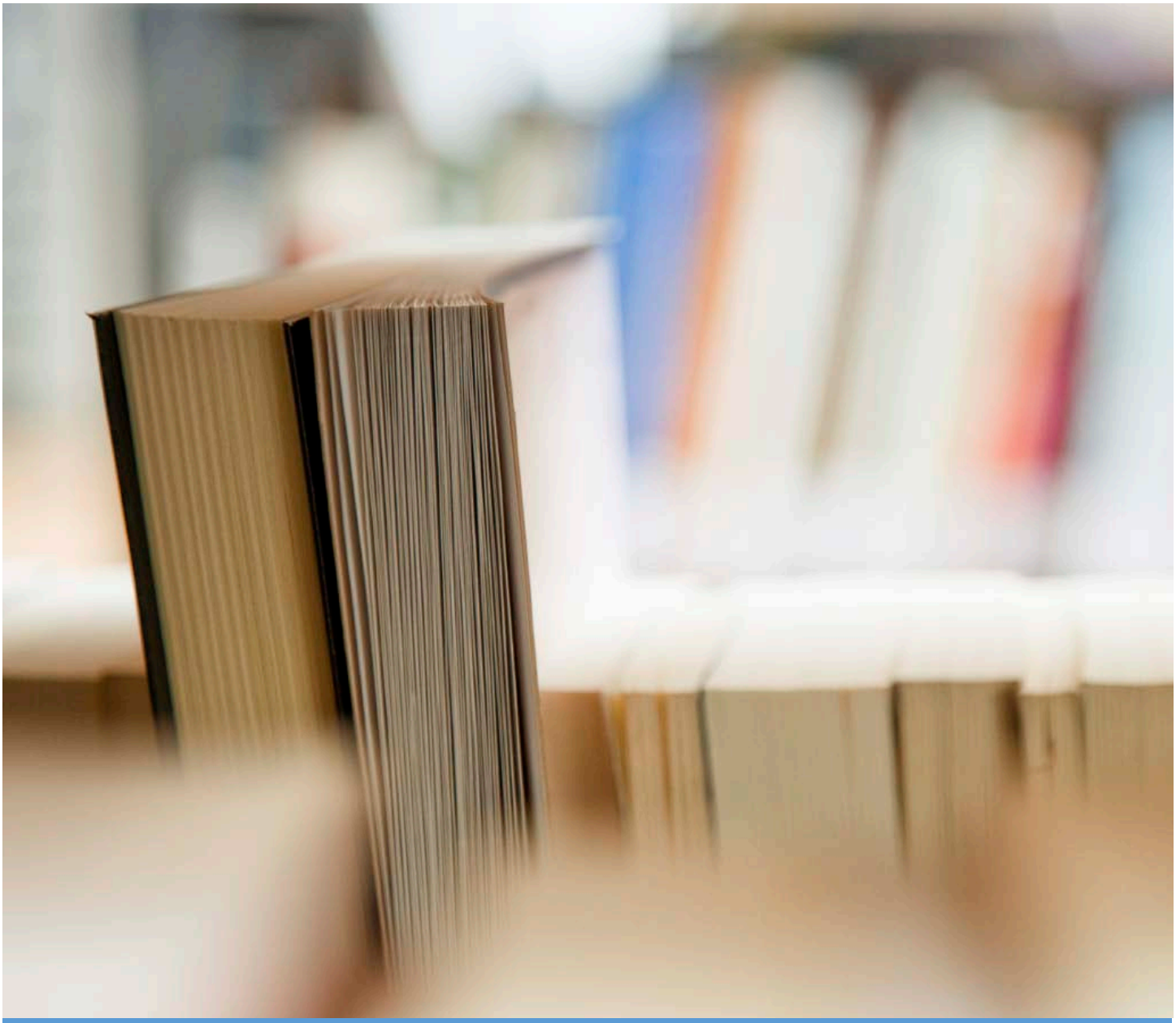

Science Style Guide

Writing and Referencing Reports

John Abbott College 2018 Sainte-Anne-De-Bellevue, Qc.

SCIENTIFIC RESEARCH OR LAB REPORT FORMATTING

Scientists write reports for a variety of reasons. Often times they are used as a way to archive procedures and results for future consultation. In a company they can be used as a way to update supervisors on the progress of a project and can often be the basis for a future publication in a journal that will share the findings with other scientists in the same field. As a student it is a valuable skill that you will be likely asked to practice. **Lab reports usually follow a specific format, and as such this document should provide you with some general guidelines. However, you should be aware that your professor may have precise requirements for their lab reports and at all times you should pay close attention to any specific guidelines they provide you with.**

PART 1 - Sections of a lab report

Grammatical etiquette for scientific reports

In general, your lab report should be brief, neutral and objective in its wording. Avoid overly complex phrasing; avoid the kind of wording that might be found in the intro of some documentary.

Since most of the time the experiment or exercise is already completed, you should only use present tense when discussing theory and use past tense throughout the rest of the document (including the methods). You should rephrase the steps and not simply recopy the lab manual as a set of instructions.

- Correct example: “The beaker was mixed until the solution dissolved.”
- Incorrect example: “Mix the beaker until the solution dissolves.”

Traditionally, scientific reports have been written in the third person, or what is known as the passive voice (e.g., ‘Solutions were prepared by mixing…’. There is now a trend towards the use of the active voice (e.g., ‘We prepared solutions by mixing…’) to promote conciseness and clarity. Recently, more and more journals (including the journals *Science* and *Nature*) encourage authors to use the active voice. You are encouraged to use the active voice, but make sure to follow any guideline set by your instructor.

Lab reports are usually broken down into the following discrete sections often indicated with underlined headings

Title Page

Your work should have a brief and descriptive title. You should also include your name (and that of your partner where applicable), your ID #s, the date submitted, the course title, the teacher's name. Note that you should verify with your teacher whether this is to be a separate cover sheet or only a headline on the top of the first page.

Abstract

The abstract is a concise summary of your report. As such it is meant to be 100 words or less and doesn't contain references (citations). Try to aim for one sentence for each of the sections of your report, in total 6 or 7 sentences. In some cases you may actual have a word count to beware of for this section. Your abstract should indicate what specific topic you are studying, what your question and hypothesis was, what your methods were, what results you found, a summary of the interpretation of your results in the discussion, and a concluding sentence. The abstract is always found at the beginning of a report or article but is often the last thing written by the author.

Introduction

The introduction should briefly explain the subject matter so that the basics can be understood by the reader. It should present the significance and importance of your work – why is your experiment relevant? A good introduction is closely tied to the scientific method in that there should be an objective to the experiment or lab, followed by a question, and then a testable hypothesis. There should also be a prediction. The prediction is a logical consequence of the hypothesis – in other words you are taking an educated guess on what you think the data will actually look like if your hypothesis is correct. Take a look at the sample experiment below adapted from Strode (2014).

Observation: Having cold hands results in loss of fine motor control.

Question: Under the assumption that breaking a toothpick in half requires fine motor skill, an experiment is designed where participants have to attempt to break toothpicks in half under different temperature conditions. What is the effect of temperature on how many toothpicks I can break in 1 minute?

Hypothesis: Low temperatures will adversely affect participants and result in a loss of fine motor skills.

Prediction: If participants break toothpicks for 1 minute after having had their hands immersed in warm water for 4 minutes and then undergo the same test after their hands have been immersed in ice water for 4 minutes. They should be able to break *significantly* more toothpicks after the warm water test.

The introduction should draw information from the scientific literature. This information must be properly referenced in the text of the introduction. In particular, background information must be given for the reader to understand and justify the question and hypothesis. Make sure that your hypothesis is supported by an explanation (a hypothesis is not just a guess).

It may be helpful to think of your introduction like a funnel. You start out wide with general information in the first few sentences and lead the reader step by step towards the narrower (more specific) ending of the intro where the thesis (hypothesis/prediction) is described.

Materials and Methods

This section usually consists of a sufficiently detailed description of the procedures that someone could use to repeat the experiment. Specific instruments or equipment used should also be mentioned. However, the standard equipment (*e.g.*, pipettes, beakers, test tubes) is usually not listed. If there were mathematical equations or statistical tests used, they should be mentioned here and then the values presented in the Results section. In this section the writer may include an in-text citation to direct the reader to a lab manual for more details.

Make sure to use chronological order for the steps followed and to take note of the "actual" steps followed. This is the time to note any discrepancies where there were deviations from the planned procedure.

Results

This section usually consists of a display of the results obtained, the results of any statistical tests, a short written paragraph describing these results, and often times a sample of the required calculations. In the paragraph presenting the results, describe what you observed (*e.g.*, trends, ranges, differences, results from the statistical analysis of the data) in light of the hypothesis that is tested (*i.e.*, focus on what the results tell you about your hypothesis). Refer to the appropriate figures and/or tables where these results are shown. Care must be taken not to actually interpret the results as this should be saved for the discussion section.

The data collected during the experiment is usually not presented in its raw form (a collection of values measured) but rather is formatted into a table or a graph. In the sciences the three most commonly used graph types are bar graphs, line graphs and scatter plots. In the following figures you have an example of a data table and the three types of graph.

Bar Graph

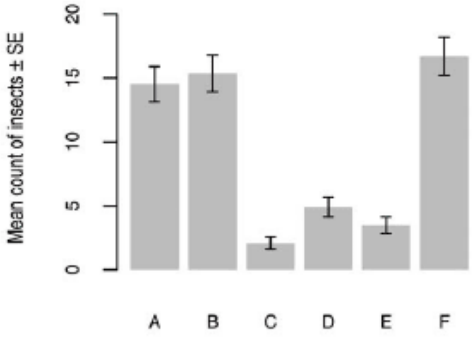

Figure 8 – A barplot representing mean count of insects caught after applications of six insecticides (data set InsectSprays). Error bars represent standard error (SE) of the mean estimated with generalized least squares (Pinheiro and Bates, 2000). Drawbacks The insecticides are ordered alphabetically even though their names have no meaning; tick mark labels at the vertical axis can be presented vertically.

Line Graph

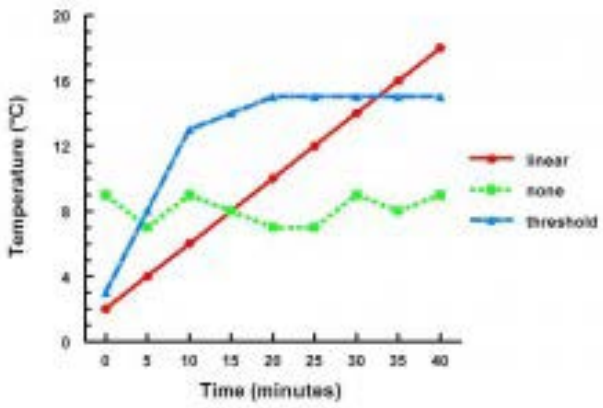

Figure 1. Text for line graph goes here (directly underneath graph). Describe the trend observed. Examples above include a linear effect of time heated on temperature of an object (red line), no response of temperature to time heated (green line), and a threshold response (blue line). I made up these numbers.

Scatter Plot (aka X-Y plot)

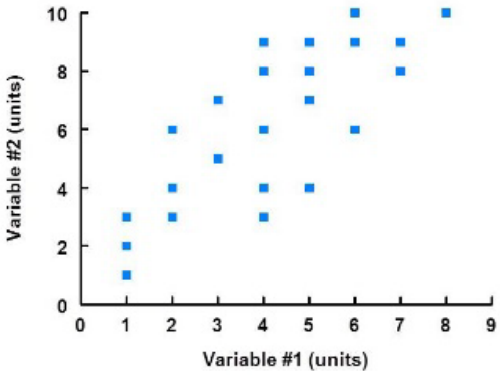

Figure 1. Text to describe the graph goes here (underneath graph). For example to describe that variable 1 and variable 2 seem positively correlated because as one increases so does the other.

Sample Table

Table 2. Log-likelihood tests of deviation from 1:1 sex ratios for nymphs collected from each population in 1997 and 1998. Values are ratios of female:male; sample sizes are in parentheses. Bonferroni corrected probabilities are shown with an asterisks.

	Year	
Population	1997	1998
Beaver Creek[T]	9.00:1(20)***	2.67:1 (22)*
Honey Creek[T]	9.00:1(56)***	2.27:1 (98)***
Rock Bridge[T]	3.33:1(26)**	2.09:1 (68)**
Cedar Creek[P]	2.05:1(119)***	1.87:1 (198)***
Grindstone Creek[P]	-	2.26:1 (140)***
Jacks Fork River[P]	2.89:1(35)**	5.17:1 (37)***
Meramec River[P]	2.80 1(38)**	2.41:1 (58)**
Little Dixie Lake[L]	2.45:1(494)***	2.46:1 (384)***
Little Prairie Lake[L]	2.38:1 (71)***	2.08:1 (157)***
Rocky Forks Lake[L]	2.55:1 (213)***	2.93:1 (299)***
Winegar Lake[L]	3.41:1 (207)***	2.34:1 (204)***
Whetstone Lake[L]	2.69:1 (381)***	2.01:1 (268)***

* significant at $p < 0.05$; ** significant at $p < 0.005$; *** significant at $p < 0.001$.
[T] = temporary stream, [P] = permanent streams, [L] = lakes.

(Kozak, 2010; Lyons, 2012; Anderson, 2012)

All tables and graphs should be labelled with a figure, or table number and a title, and should have a brief sentence of description as above. For a <u>figure/graph</u> this information should appear below, but for a <u>table</u> this information should appear at the top.

Imagine a picture from one of your textbooks, like the one below – they are usually formatted like this. The Figure number is Fig 2.2; the title is "The emergent properties of a compound" and the rest of the sentence below is the descriptive legend.

▲ **Figure 2.2 The emergent properties of a compound.** The metal sodium combines with the poisonous gas chlorine, forming the edible compound sodium chloride, or table salt.

(Campbell and Reece, 2005)

A few important points to consider when preparing your graphs:

- You should favor graphs over tables. Only use tables if absolutely necessary.
- Make sure to present the dependent variable on the *y* axis, and the independent variable on the *x* axis.
- When the independent variable (*x* axis) is a continuous variable, then you should use a line graph or scatter plot. Bar graphs should only be used when the independent variable is discrete.
- Axes must be accurately labeled.
- A trend line (with equation and r^2 value) can be included when a mathematical function satisfactorily describes the relationship between the variables (*e.g.*, no linear trend line if the data is clearly not linear).

Discussion and Conclusion

The discussion is a detailed interpretation and explanation of the results. This is usually considered to be the most important part of the report and where you as a student will demonstrate that you have gained an understanding of the topic that goes beyond simple procedures and calculations. The discussion should start with a brief statement highlighting the main results (those that are relevant to test your hypothesis). There must be a clear decision regarding accepting or rejecting your hypothesis early in the discussion. This is also where you will attempt to explain your results and interpret them within the topic you are studying. Think of it as trying to answer two basic questions:

What do my results show? (explain)

What do my results mean? (interpret)

This is also the place where you should explain any discrepancies in your results. In particular, the limitations of the experimental setup must be acknowledged when discussing the results. This should not be a simple statement of a few sources of error, but rather a critical analysis of the validity of your results and the scope of your conclusions.

Often times your teacher may require you to link results obtained with concepts found in other scientific publications or with specific theories or physical laws. The concepts from the scientific literature must contribute to explain the results obtained. Make sure to properly reference these concepts. Throughout this section you should make certain to refer back to your figures and tables only by their proper diagram numbers (*e.g.* "As can be seen from Fig. 3, the relationship of temperature versus pressure is roughly linear.")

The conclusion is a brief statement (2-3 sentences) that summarizes the main points of the discussion and the general findings of the research or lab activity, and often suggests a direction for future work. Although the hypothesis is often mentioned again, the conclusion should be more general in tone than the rest of the discussion.

References

References play a fundamental role in the scientific literature. You have to show that your work fits in a body of knowledge. References support the background information in your introduction, and the explanation of your results in the discussion. You can see references as links to previous knowledge that your work builds upon.

References can often include your lab manual or your course textbook, but other than those you will most likely be finding outside material to reference your work, including textbooks and peer-reviewed scientific articles. Be very careful here to get specific guidelines from your professor for what types of sources you should be consulting.

How can I find sources to use for referencing?

The most inefficient way to search for peer-reviewed material is to do a basic Google search. This will often give you widely varying types of documents and some of what you find may be behind a paywall (you will have to pay to access the full document). A better way would be to use one of the academic search engines listed below:

- John Abbott's Online Library Databases
- Google Scholar (scholar.google.com)
- sciencedirect.com
- PubMed (ncbi.nlm.nih.gov/pubmed/) for biological sources only

These will at least give you access to the abstract. The rest of the article may be behind a paywall. Some journals are open access, *i.e.* there is no need to pay a fee or have a subscription to access them. If you found an article of interest and you need to read more than just the abstract, you can use ResearchGate (researchgate.net). This is a website where scientists post their articles (published in scientific journals) – these are provided free of charge. Search by author (usually the first author) and chances are that you will get to their page with free access to their articles.

How do I know if I can use the source I have found?

Many sources will be inappropriate for a scientific report unless specifically suggested by your teacher. Some inappropriate sources are personal websites or blogs, newspaper articles (The Gazette, Le Journal de Montréal), news websites (Huffington Post, etc.) and Wikipedia. Keep in mind that some of these sources can still be considered useful as a starting point providing you fully research them. For instance, in a Huffington Post news article they may talk about a discovery made by a researcher. If this is useful info to you then look up the actual researcher and find their actual publications or their lab's website. And nowadays Wikipedia usually contains a list of references at the bottom – go find those. So if using Wikipedia as a first step in your research, be sure to follow the links to the primary reference; these are listed at the end of the Wikipedia page. At no point should Wikipedia itself be used as a reference. And in the simplest of terms if you cannot find someone listed as an author for a piece of information – then you cannot use that for one of these references.

Also note that references are not the same as a bibliography. A bibliography is a list of sources that you consulted in order to research your topic and they are normally not mentioned within the text of the report. A reference list is accompanied by citations, where every reference listed must also be found in the form of a citation within the document. Throughout your report (mainly within introduction, methods, and discussion) you will have to indicate where a statement or idea has been taken from someone else. In science this is usually called a citation, an in-text mention of the source.

In addition, the reference you have found may be used and cited more than once in the report.

Referencing can be quite complicated so part 2 of this document contains a detailed procedure for formatting references and their accompanying citations.

PART 2 - Referencing

Scientific referencing norms are set by the Council of Science Editors (CSE) and fall into one of two main citation styles. Make certain to note which style is preferred by your teacher before completing your document.

Note that in scientific writing, direct quotes are rarely used. It is customary to rephrase the information taken from the source and include the citation to indicate where this information was found.

Citation Style 1 – Name and Year:

The in text citation will be in the format of (Author's last name, year of publication) and the list of sources in the reference section will be arranged alphabetical by last name of the first author. The exact formatting of the citation will depend on how many authors the paper has.

One author

The book: Environmental Organic Chemistry written by PM Gschwend in 2016 will show up in text as (Gschwend, 2016).

Two authors

The journal article: Black Holes at the large Hadron Collider written by Savas Dimopoulos and Greg Landsberg in 2001 will show up in text as (Dimopoulos & Landsberg, 2001).

3 or more authors

The article: Post-transcriptional regulation of meiotic genes by a nuclear RNA silencing complex written by ED Egan, CR Braun, SP Gygi, and D Moazed in 2014 will show up in text as (Egan *et al*., 2014).

Citation Style 2 – Citation Sequence

The first time a source is used in the text it will be assigned a number shown in superscript (e.g. ^{3}). This source will show up in the rest of the document using the same number. References at the end will be numbered and be arranged numerically by their order of first use in the document.

For example, in a report if the 5th citation used is the article from above by Savas Dimopoulos and Greg Landsberg, then the citation might look something like this the first time it is used: The energy spectrum of the decay products could test Hawking's evaporation law^{5}.

In any further use of the reference it will retain its designation as ^{5}. And many references can be cited at the same time by simply listing the numbers separated by commas. If in the above example statement, the article by Dimopoulos and

Landsberg was not the only source that mentioned Hawking's Law, the citation would look like this: The energy spectrum of the decay products could test Hawking's evaporation law[2,5,8].

Formatting sources in your reference section

All the sources that were referenced in the text should be included in a reference list at the end of your work. Remember that a reference list is not a bibliography, *i.e*. do not include sources that were not explicitly referred to in the text. Do not provide the URL's for published references. The URL is the article repository, *i.e.* where you got it from. The actual reference is important, not where you got it from (a library or a website). Here are the 3 main formats in order of credibility starting with the most reliable.

1) Journal Articles

Author last name and initials. Year. Title of the article. Name of journal. Volume(Issue):page numbers

Example: Courtois R., Bernatchez L., Ouellet J.P., Breton L. 2003 Significance of caribou (*Rangifer tarandus*) ecotypes from a molecular genetics viewpoint. Conservation Genetics 4(3):393-404

Some notes:

- All authors of a paper need to appear here (no use of *et al.*).
- Italics are not used (except for the scientific name of a species) in the title and only the first word of it should be capitalized.
- Longer journal names usually have an official abbreviation and if you can find the abbreviation, it can be used here to save space. For example, the Journal of Research in Astronomy and Astrophysics has the official abbreviation: Res. Astron. Astrophys.
- Also note that the lack of spacing in the section listing volume and page numbers is deliberate.

2) Books

Author's last name and initials. Year. Title. Edition (if applicable 2nd, 3rd etc). City of Publication: Publishing Company; Number of pages.

Example: Rowling J.K. 1997. Harry Potter and the Philosopher's Stone. London (United Kingdom): Bloomsbury; p. 67-69.

3) Websites

Website name. Date. Title or heading of page. City:Company; [Date updated; date you are citing it] website URL

Example: Space.com. 2018. Astronaut Scott Kelly and His Twin Brother Are Still Identical. New York: Purch Publishing; [Updated 2018 Mar 16; Cited 2018 Mar 19] Available from: https://www.space.com/40007-astronauts-scott-mark-kelly-still-identical.html

- Make sure that this format is only used for genuine websites. If you find a published journal article online, it should still be formatted as below, and no URL should be given.
- **Please note that websites are usually not accepted as references in scientific publications and lab reports, since they are not peer-reviewed scientific literature. Exceptions include governmental websites providing specific verified information or analysis (*e.g.*, Statistics Canada).**

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