

Writing a Research Report

Following is a set of guidelines that I often hand out, in modified form, to help my students write a scientific research paper. Remember that the goal of a research paper in science is mostly to present original research. Scientific review papers, by contrast, mostly serve to summarize the work of other researchers. They present very little, if any, new information.

These guidelines reflect a fairly standard protocol for the research paper. However, do be advised that various teachers and professional journals may present variations on these basics. Some journals have standardized headings that differ from those presented herein. Others do not use headings.

Remember that when you write in science, you are writing for an audience. Scientific writing is also filled with tradition and attention to style and formatting. Read or at least look over several published research papers to help you become familiar with scientific writing protocols. This is one of the most effective ways to improve scientific writing habits.

Abstract

An abstract is a short summary of your entire paper that is usually no more than a few sentences in length. It will probably be written last but it is always placed first in a research paper. An abstract may also be called a summary. It is often set apart by being printed in a different font effect such as italics or bold. Think of the abstract as a “quick read” for your paper. It can easily let a reader know if he or she may find the whole paper valuable. Avoid tedious detail in the abstract but make it complete. Don’t forget to include a quick summary of your result.

Introduction

As the name implies, this section serves to introduce the reader to the research project about which the paper is written. It is good practice to include a well written research question and a hypothesis in this section. Remember that a question should end with a question mark and it should pose a specific, empirically testable inquiry. A hypothesis is a declarative statement that attempts to “answer” the research question. It is a prediction. Like good questions, good hypotheses are specific and testable. In science, good questions and hypotheses typically link two variables, the manipulated variable and the measured variable. Questions of this type are often called “covariation questions.” In some types of biological research, such as descriptive studies, formal questions and hypotheses may be lacking. Yet, a primary goal of the introduction remains in giving the reader some information about the study they are reading.

Another vital goal of the introduction is to provide the reader with background information. Some writers and journals consider this a separate section and often refer to it as a “Review of the Literature” or by some similar title. In other words one should cite and discuss

a few peer reviewed scientific research and review papers that have been published pertaining to the topic of the research. These papers may be peripherally or directly related to the paper being written. In actual scientific practice, it is actually a good thing if one is unable to locate other studies exactly like his own. This may mean that the researcher has original research findings to share with the larger scientific community. However, this does not allow the writer to gloss over background information pertinent to the study. Following is a partial list of some information that may be found in a good review of the literature.

- Information about the organism that is the subject of research. Where is the organism found? What is its scientific name? What are some interesting things about the organism? What other types of research have been done involving this organism?
- Have studies similar to the one you completed been done? If so, who did them and when? What were the conclusions of this research? Perhaps you are writing about the effect of cold temperature on the reproductive habits of a particular species of fish. If you run across a study that sounds a lot like your own, but involving another species of fish or even some other type of organism, it may be good to cite and discuss that study.
- Could you comment about why research such as yours is needed? Is there a potential economic benefit or a medical benefit? Is the habitat you are researching poorly understood? Perhaps the research organism is a household pest or perhaps it is a biologically threatened species. Discuss these things, citing published scientific writing, as you do so.
- Historical research trends may be important in a literature review/introduction as well. For example, who first published the laboratory protocol you are using? Was there a similar one that has been replaced by a more modern one? What other researchers are now working on problems similar to the one you are dealing with? What findings have they published?

As you work, you must cite the references you are consulting in the body of the paper as well as in the "References Cited" section. Be sure to use quotation marks to identify shorter direct quotations from sources. Use block quotation formation for longer direct quotations.

Remember that you must cite the source for ALL use of published references, even if you paraphrase the source by putting the information in your own words. A good rule of thumb is to cite anything that the average person on the street may not know. In the case of professional citations, overkill is better. However, it is not necessary to repeatedly cite the same source within a paragraph unless it is used with other sources or mixed with the author's own ideas. Cite a particular reference each time you "change gears" so to speak but there is no need to repeatedly cite it if it is continuously used as you write an extended body of text based solely on that reference.

EXAMPLE:

To Be Avoided

These organisms are found in Asia (Jackson, 2010). Native people of the area often use them in traditional medicine (Jackson, 2010). They have been known to western scientists since the mid 1800's (Jackson, 2010).

To Be Encouraged

The organisms are found in Asia and have been known to western scientists since the mid 1800's. It is of note that native people of the area often use them in traditional medicine (Jackson, 2010).

Another Variation to Be Encouraged:

The organisms are found in Asia (Jackson, 2010). They were first formally described by Cole (1884) but have been known to western scientists since the mid 1800's (Jackson, 2010). A major study involving analysis of the plant's chemical composition failed to identify any medically active components (Forsyth, Jones & Watkins, 1956). However, native people continue to use the plant in their traditional medical practices (Jackson, 2010).

It is a bad idea to rely on only one or even a few published references. Cite from a variety of sources and from numerous sources to strengthen your introduction. Remember that the citations you make should match your reference list. In other words, do not cite a source as "Smith, 2009" in the body of your paper while listing it as "Wildlife Encyclopedia" in your reference list. A reader should be able to easily locate a reference entry you have cited in the reference list.

A well written introduction is typically substantial. In some cases the writing may go on for several pages. It is difficult to imagine a well written introduction and literature review that is fewer than three to five extended paragraphs in length.

Methods & Materials

This section may sometimes simply be called "methods" or "procedure" among other things. The purpose of this segment is to provide clear detail about how you tested your hypothesis or otherwise carried out your original research. The goal is to allow a reader to understand your procedure well enough that she could replicate your study exactly or nearly exactly. Remember, you are writing for an audience. Leave nothing to the imagination. It is sometimes necessary to cite and briefly discuss published references in this section. For example, you may be using a statistical test that needs to be briefly defined or you may be using

a research protocol developed by another scientist. If you find yourself writing more than a couple of sentences about cases like these, they are probably better described in the introduction of the paper.

In the introduction you should be specific with numbers, measurements, length of time and other critical details. Use International System units, not English system units. Dates are usually very unimportant in scientific research and their use in a formal research report should be avoided. To help the reader keep track of time (which you should meticulously record WITH DATES in your lab notes) use the phrase “days from start” and abbreviate it (DFS) after you first use it. You may also use phrases like “day one” or “week seven.” Depending on the type of research it may be appropriate to note the season or time of day. For example, snakes may behave very differently during a mid summer day than they would during a cool fall morning. In each case, though, listing temperatures makes the whole description more scientific and standardized.

Another precaution is to avoid mixing results in this section. Remember that “Methods and Materials” concerns what you did, not the outcome. Even if you complete multiple trials or experiments with slightly varied procedures, do not report results in this section.

Following is a table illustrating some good and bad practices in writing “Methods and Materials.”

Bad Choices...to be Avoided	Better Choices...to be Encouraged
<ul style="list-style-type: none"> * We put the bugs in an incubator in the biology classroom. * The seeds were sprouted in pots of dirt. * On Tuesday, November 19th we crushed up some strawberries in a blender. On Thursday, November 21st, we used them to get out the DNA. * We kept the control fish warm and under normal light. 	<ul style="list-style-type: none"> * All cultures containing the research organism were incubated at 29 °C, in darkness, for 12 days. * Twenty five seeds were planted in each of ten plastic potting containers. The containers measured 15 cm in height and 10 cm in diameter and were filled with 60 g of commercially prepared potting soil. * On day one, 357 g of <i>Fragaria ×ananassa</i> fruit was homogenized in a blender. Two days later DNA was extracted from the macerated fruit solution using the protocol described by Smith (1998). Commercially prepared DNA extracting solution from Jackson Scientific Company was used. * By way of an electric aquarium heater, the temperature of the aquarium was maintained at between 21 – 24 °C. A 15 watt fluorescent bulb, controlled by a timer, provided a

	consistent 8.5 hour photoperiod.
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Results

Describe in detail what happened during your experiment. How did the experiment turn out? Summarize your data with clearly labeled and carefully constructed inscriptions such as charts, tables or graphs as appropriate. You may or may not need to include diagrams and/or photographs as well. Make sure all inscriptions have appropriate titles and include units of measurement if needed. Number the inscriptions consecutively (using separate numbering for Tables and Figures; begin with Table 1 and Figure 1) and refer to them in the text of the results section. Avoid including inscriptions that are not referred to in the text of your paper. Use numbers and good quality descriptions as you report your results. How high is up? How tall is tall? How many is in a bunch? How long is a long time? Avoid mixing discussions and/or conclusions in this section. Following is a table illustrating some good and bad practices in writing “Results.”

Bad Choices...to be Avoided	Better Choices...to be Encouraged
* We found a difference between the two groups.	* Figure 2 presents a comparison of the average increase in height in both groups.
* Survival was much better in the control group than in the experimental group.	* As summarized in Table 6, during the first trial, 26 organisms survived in the control group compared with 12 in the experimental group.
* Since we had more growth in group A, our hypothesis is proven.	* Group A showed 12% more growth than Group B and 17.5% more than Group C. The possible significance of this difference will be discussed in the section entitled “Conclusions.”

Conclusion

This section is sometimes called “Discussion.” This section is where you discuss and evaluate your hypothesis based on the results of your experiment. Did you find evidence to support your hypothesis? Refer your readers back to important results as you discuss this. Remember that this section largely involves your opinions about the experimental evidence. Suggest how to improve your procedure for future research projects that may be done on this topic. Discuss other questions your work may have raised. It is a good practice to avoid using

words like “proved” or “disproved” as you discuss results and evaluate a hypothesis. Your goal is to comment on whether or not you found evidence, or failed to find evidence, to support your hypothesis. Following is a table illustrating some good and bad practices in writing “Conclusion.”

Bad Choices...to be Avoided	Better Choices...to be Encouraged
<p>* We proved our hypothesis beyond a doubt.</p> <p>* The whole experiment was a failure.</p> <p>* The hypothesis was disproven. Light was the cause.</p>	<p>* As summarized in Table 4, and as discussed in the section entitled “Results” we found substantial evidence to support the hypothesis that increased exposure to light accelerates time until flowering.</p> <p>* The methods employed in the experiment were problematic. We suggest that future researchers interested in <i>Porcellio scaber</i> reproduction pay careful attention to the temperature of the incubation container. This is consistent with recommendations made by Jones, Hardin & Thompson (1938) and discussed in the introduction to the current paper.</p> <p>* Our evidence, detailed in the section titled Results and summarized in Tables 1 through 6, clearly does not support our prediction. We believe that light may be important and recommend that future researchers concentrate on this area.</p>

References Cited

For research and review papers in science, you should use mostly *peer reviewed scientific journals* for your references. Limited use of textbooks or manuals may be appropriate but they should comprise only a few of your reference entries. Do not necessarily avoid a reference because it is “old.” It may have tremendous historical value as you develop your introduction or it may be regarded as a definitive reference on the subject. Use “Google Scholar” or various scientific abstracts in the library to help you locate references. List each of the references that you consulted while writing your paper. Include names of authors, dates of publication; names of books, journals, articles, etc. If you do not know how to write a References Cited page or how to cite published literature, look at other published papers, see your teacher or consult a writing tutor or assistant. Alphabetize all entries by the authors’ last names. Your reference list and your citations in the text of your paper should match. The reader should be able to go to

your reference list and very easily locate a book you cited in your paper. She should be able to locate that book by following your information. Keep in mind that publishers and editors often have very specific guidelines and protocols to be used when writing for them. Here are some generally agreed upon good and bad practices.

Bad Choices...to be Avoided	Better Choices...to be Encouraged
<p>EXAMPLE ONE</p> <p><i>From the text of the paper</i></p> <p>In the book Rainforests it states that the flowers bloom once each year.</p> <p><i>From the References Cited list</i></p> <p>Beth Jones Rainforests</p>	<p>The flowers appear once each year (Jones, 2009).</p> <p>Jones, B. (2009). <i>Rainforests</i>. New York, Sylva Publishing House.</p>
<p>EXAMPLE TWO</p> <p><i>From the References Cited list</i></p> <p>Biology Book</p>	<p>Westbrooks, J. A., Johnson, F. & Clinton, M. L. (2006). <i>Foundations of Biology</i>. London, All Science Publishing.</p>
<p>EXAMPLE THREE</p> <p><i>From the References Cited list</i></p> <p>Internet</p>	<p>Westinghouse Health Services. (no date). <i>Cockroaches in Your Home: A Guide for Safe Pesticide Use with Pets</i>. Retrieved from www.westinghousehealth/pets.com on March 5, 2009.</p>

Final Tips

- Proofread your paper. Do not rely only on your computer's spell check and grammar check features.

- Have at least one other person to proofread your paper as well. It is very difficult to catch mistakes in your own writing.
- If you are working with coauthors, have EVERYONE in the group to read and approve the final draft.
- Keep multiple forms of back up copies throughout the writing process. Do not rely on only one form of back up.