

Guide to Writing a Science Research* Paper

A well-written scientific research paper explains the scientists' reasons for doing their research, how the research was performed, what the results were and a discussion of the results. Scientific papers are written in a direct and succinct style that seems dry to many people outside of science. There is a sound reason for this style. There are thousands of scientific and technical articles published every week. Each week, there are hundreds of articles published in very specialized fields of science. To allow scientists to keep up with this progress, scientists have devised a very efficient format of communicating their findings. That format is what will be described in this instructional lesson. If you are writing a simple short report for a small experiment you performed in a classroom, the format will be the same but the extent to which you write each section will be much simpler.

The skill of scientific writing is valuable in many ways outside of science. Many scientists have been very successful writers of popular novels. Francis Bacon in his book *Novum Organum* was one of the great authors of the 17th century and one of the first people to clearly write about how science uses a logical approach of experimentation to show why things in nature are what they are.

The following sections should be included in your science paper

(1) Abstract (2) Introduction (3) Methods (4) Results (5) Discussion (6) Literature Cited

It is important to put information in the appropriate sections. It is common for beginning science writers to discuss results in the wrong sections. A common error is to discuss why results turned out as they did in the Results section. The Results section only reports the results.

Reading scientific papers will help a great deal but remember that there are thousands of scientific and technical journals and the format can vary significantly in appearance. Nevertheless, they are useful as models for your writing.

One cautionary note... it is difficult to put some notions into your own words. Remember to pay attention to issues of plagiarism. One useful way to avoid this is to put others' writings in quotes and give the citation for the source.

**Research in science typically implies work that involved experimentation. Literature research is a different sort of thing...to a scientist.*

INTRODUCTION

The Introduction begins with general information and eases the reader into the subject. It begins often with background information that frames why the subject is of interest. This background is usually done in a paragraph or two. As you get into the body of the intro, you address more specifically what your research addressed

The last sentences of the introduction often state the objectives of your experiments and sometimes provide a hypothesis. This provides a transition to the Methods & Material section. For example, "Our objective was to determine if growing thousands of showy lady's slippers and planting them under a variety of conditions would provide a means to help protect this plant from extinction."

M&M

It should be a narrative of the steps you took in your experiments. It is not a cookbook list of instructions. You should assume that the reader has the same basic skills that you have, but could reproduce your work with the details you are providing. For example, it is unnecessary to write, "We used a graduated cylinder to measure and dispense 650 milliliters of distilled water in a 100 milliliter glass beaker." You would write, "We dispensed 650 mls of distilled water." Here you are assuming the reader knows what to use to dispense common fluids.

Writing a succinct but informative paper involves a balancing act of knowing what to include and what to omit. Much of this will come with experience. A reasonable guide is to err on the side of more information and then when you edit your paper it is easier to omit than go back and add.

In the last paragraph often provides a description of statistical tests you used (statistics are methods).

RESULTS

This section presents the findings, observations, measurements etc. without proposing what they would lead one to conclude.

The challenge is knowing what information to include or omit. The results section is typically by far the most work since you must prepare the data. This means taking observations that are often in spreadsheets and making tables and graphs that are easier to understand. Use the text of the paper to state the results of your study, then refer to a table or figure For example you may write, “Three % of lady’s slipper seed by 6 weeks and increased to 17% by 8 weeks in culture. (Figure 1)”

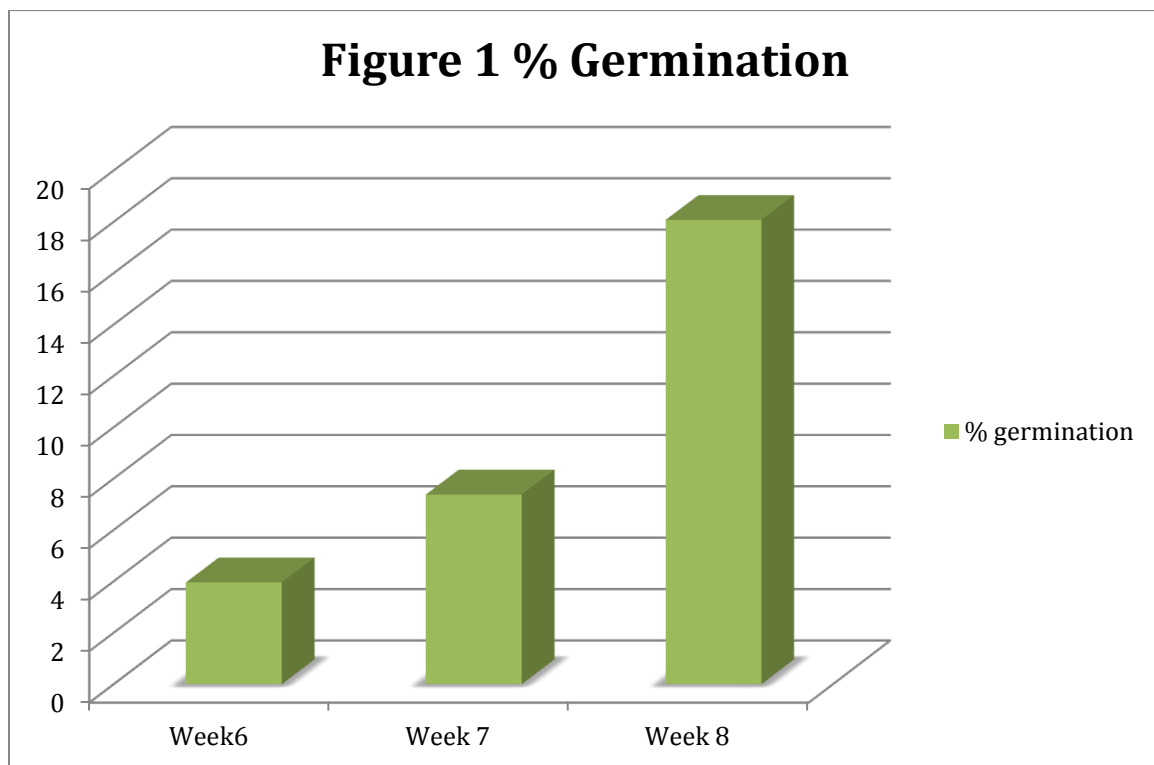


Figure 1 Seeds germinated in culture. Each week represents germination from 40 tubes of *C. reginae* with about 20 seeds per tube.

Note that below the graph there is a description of what the graph represents. The graph also has a legend. Do not include the same data in both a table and a figure.

Additional tips on the Results section:

- Number tables and figures separately (i.e., Table 1, Table 2, Figure 1, Figure 2, etc.).
- In the text, refer to each figure or table. Do not report data that is not shown in a graph or table. Do not show graphs, tables or pictures you do not address in writing in the text of the results.
- Use pictures when necessary.
- Tables generally should report summary-level data, such as means \pm standard deviations, rather than all your raw data. A long list of all your individual observations will mean much less than a few concise, easy-to-read tables or figures that bring out the main findings of your study.
- Figures (graphs, pictures, drawing, illustrations) are generally more informative than tables with numbers... a picture is worth a thousand numbers. Uses tables of numbers when you want to have greater specific resolution of the data.

DISCUSSION

Here is where you explain the results. What are the implications of your findings? What conclusions you can make. How do these findings accomplish what you set out as goals in your Introduction? Do they support any hypotheses you made in the Introduction?

When you make conclusions, refer to the data in your paper that supports those conclusions. You should also interpret your results based on the findings of other published papers.

Relate your discussion back to the objectives and questions you raised in the Introduction section. However, do not simply re-state the objectives. Make statements that synthesize all the evidence (including the work of other scientists).

Do not make statements that are too conclusive. A commonly misused word is “proved”. Careful scientists seldom use this word since it implies that it is irrefutably the case. Limit your conclusions to more modest statements such as, “our data suggest”. You can speculate on why something did or did not occur as expected and suggest further work that will help in your research. If necessary, point out unusual or contradictory results and pose explanations if possible.

Citations

This is the last section of the paper. Here you should provide listing of all the published work you referred to in the text of the paper.

One format that is used, cites literature in the text in the order in which they appear and to list these references in the Literature Cited section not in alphabetical order but in the order in which they appear in the text. Other approaches use the old alphabetical order. The style will depend on the publisher...The journal "Science" uses the number approach.

Every scientific journal in which I have published has an extensive set of instructions the authors must follow to publish in that journal. None of them have been exactly the same but all follow the same general style set out in this instructional paper.