

How to Write a Scientific Paper?

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A scientist's life would be happy one if he had only to observe and never to write (Charles Darwin). However, in science, no matter how spectacular the results are, the work is not completed until the results are published.

The purpose of this presentation is to help students to prepare the manuscript and to show all steps from the rough manuscript to published paper.

There are different kinds of scientific written communications like

Reports, theses or dissertations, journal articles, slide presentations, posters, books and book chapters, technical manuals/users guides and research or grant proposals.

Overview

A critical aspect of the scientific process is the reporting of new results in scientific journals in order to disseminate that information to the larger community of scientists. Communication of your results contributes to the pool of knowledge within your discipline (and others!) and very often provides information that helps others interpret their own experimental results. Most journals accept papers for publication only after peer review by a small group of scientists who work in the same field and who recommend the paper be published (usually with some revision).

You should always put in mind that the format and structure presented here is a general one that will enable you to adapt easily to most journal- or discipline-specific formats. However, this guide will not teach you how to write in the English language, i.e., it is not a grammar book. You, the "future" writer, must practice writing and thinking within this structure, and, learn by example from the writings of others; learning the nuances of this style and format will be enhanced as you read the scientific literature - pay attention to how professional scientists write about their work. You will see improvement in your own scientific writing skills by repeatedly practicing reading, writing, and critiquing of other's writing.

All journals have a set of instructions for authors which explicitly state how their paper should be

formatted for submission. You are kindly requested to follow the directions carefully and to make full use of this guide as you prepare your papers. Please ask for help if you have questions about format, style, or content. Above all, remember to write with precision, clarity, and economy.

Getting Started

The first task to accomplish as you begin the process of writing is to order and organize the information you wish to present. Some people work well from an outline, others do not. Some people write first to discover the points, then rearrange them using an after-the-fact outline. Whatever process you may use, be aware that scientific writing requires special attention to order and organization. Because the paper will be divided into sections, you need to know what information will go into each. If you don't normally work from an outline, this may be an occasion when you'll at least want to develop a list of the major points to be included in each section, before you begin to write. If the paper has multiple authors, then this is a good time to work (and negotiate!) with your collaborators to insure that all the points the group wants to make get listed.

Audience: Who will be reading your paper? Usually you will be writing to your peers.

How would you narrate it?

Your writing should be in complete sentences and easily understood. Remember that although English is NOT your NATIVE Language, your writings should conform to the conventions of standard written English (sentence form, grammar, spelling, etc.). Your ideas will have little impact, no matter how well the research, if they are not communicated well. Remember always that scientific terminology very often has precise meaning. Be certain you choose your words correctly and wisely.

It is important to write clearly and concisely. Make sure that every paragraph has a clear topic sentence and that the paragraph content supports the topic. The goal is to report your findings and conclusions clearly, and with as few words as necessary. Your audience (other scientists usually) are not interested in flowery prose, they want to know your findings.

Remember: Writing and thinking are closely linked enterprises - many people have noted that,

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"fuzzy writing reflects fuzzy thinking" When people have difficulty translating their ideas into words, they generally do not know the material as well as they think.

Style Considerations

Be clear and concise: Write briefly and to the point. Say what you mean clearly and avoid embellishment with unnecessary words or phrases. Brevity is very important. Use of the active voice alone shortens sentence length considerably.

Precise word use is critical: Scientific terminology carries specific meaning - learn to use it appropriately and use it consistently. A critical function of technical terminology is to say a lot with a few words, i.e., economy. This applies as well to appropriate acronyms (e.g., PCR) and abbreviations. Direct your paper toward the average reader in your intended audience. If writing for a highly technical journal, you will necessarily use the technical jargon. If writing for a general science audience you would limit the jargon.

Some things to avoid

You do not have to try to impress people by using words most people have never heard of. Many published articles are like this, and they are poor papers on account of it.

Do not use contractions; for example, "don't" must be "do not" and "isn't" must be "is not" etc.

Do not use abbreviations in the text except for units of measure. Always abbreviate these when using them with data (2 mm; 10 min.). Except for temperature units, never abbreviate units of measure when using them in a non-data context (e.g., "we measured length in millimeters"; "time was recorded in minutes"; "temperature was measured in F (or C)"; "100 years have passed since Mendel did...").

Use Past Tense; Research papers reflect work that has been completed, therefore use the past tense throughout your paper (including the Introduction) when referring to the actual work that you did, including statements about your expectations or hypotheses. Use the past tense, as well, when referring to the work of others that you may cite.

Use Active Verbs; Use active verbs whenever possible; writing that overly uses passive verbs (is, was, has, have, had) is deadly to read and almost always results in more words than necessary to say the same thing.

The clarity and effectiveness of your writing will improve dramatically as you increase the use of the active voice.

Other specific comments on style are also included for each section of the paper.

Remember precise word use, past tense, active voice, brevity.

References to the research findings of others are an integral component of any research paper. The usual practice is to summarize the finding or other information in your own words and then cite the source. Any ideas or other information that are not your own must be substantiated by a reference that is cited in the text. As a rule, in research papers, direct quotation and footnoting are not practiced - simply restate the author's ideas or findings in your own words and provide a citation.

Plagiarism (use of others words, ideas, images, etc. without citation) is not to be tolerated and can be easily avoided by adequately referencing any and all information you use from other sources. In the strictest sense, plagiarism is representation of the work of others as being your work. Paraphrasing other's words too closely may be considered as plagiarism in some circumstances.

Writing Your Paper

The scientific paper is traditionally divided into four sections: introduction, patients and methods, results, and discussion. These sections are typically completed through an iterative process because no single section can be written without consideration of another. The introduction is compiled from reference material and reflects the thought processes or lines of reason that lead you to perform your research. The remainder of the paper is constructed concurrently as the work is constructed and planned. In the final draft the organization of the materials and methods section is coordinated with the results section. The results section presents pertinent data in nearly chronological order and directs the reader along the same mental paths through the data that you took in solving the problem. The discussion section provides interpretation of the data and projections as to the meaning of the results. The use of good references throughout the paper gives the work credibility by demonstrating an awareness of previous works.

Writing a scientific article is not an easy task no matter how simple the actual experiment or concept. Practice, good planning, and organized record keeping are the only means to simplify the process.

This Should Go in the Following Order

Introduction

The Introduction should "introduce" the paper. The reader should be presented with enough background information to be able to understand and evaluate the purpose of your study without having to refer to other works. The rationale for

the study should be presented. Provide salient references but avoid trying to make an exhaustive review of the topic.

In the introduction, define the problem clearly. If the problem is not stated in a reasonable, understandable way, the reader will have no interest in your solution. Follow with some review of the literature to allow the reader to understand why the study is necessary and how you attempted to resolve it. Talk in general terms about techniques used to solve the problem, if necessary, but do not present any specifics about the protocols here. The final portion should be the statement of the principal results.

- Present the nature and the scope of the problem investigated.
- Provide enough background to orient the reader and justify the study.
- State the goal/objectives and method of the investigation.
- Briefly state the principal results of the investigation.

Materials and Methods

This section should be the easiest to write if you have good notebook skills. A well written patients and method section allows a competent scientist to duplicate your results.

You should start this section by mentioning where you conducted your research and the type of this study. A brief mentioning on the sample size and how it was calculated is essential.

Present specific information about your patients. What were the characteristics of your patients? How did you select them? Were there any exclusion criteria, did the process involve any randomization? If yes, how did you randomize them?

Appropriate terminology and definition of the techniques used is mandatory with adequate referencing whenever needed. This may prevent you from repeating unnecessary information if they are widely known. On the other hand detailed description of your work are needed if your work is original and involve new procedures, surgical interventions and likewise.

Specific Primary as well as surrogate endpoints should also be mentioned in details as well as the way they were measured.

Cite which statistical tests you used and explain the reason behind choosing each of them.

Results

- Open the *Results* section by presenting the "big picture" or overview what you have done. Focus on the theoretical question at hand and do not repeat the details described in the section on the

material and methods. Orient and prepare the reader for the data that follows.

- The data must direct the reader toward the solution to the problem.
- Organize the data in logical steps that describe the trail of investigation you followed in order to reach your conclusions. If your logic is sound, the reader will easily understand why you performed certain measurements and will be interested in the actual data obtained.
- Data is presented in text, tables or graphs depending on the material and the emphasis that you desire. Look at published examples of graph and table presentation and mimic that style. There is no harm in that and this is not considered as plagiarism.
- Each figure or graph must be able to "stand alone" with its figure legend. A descriptive title includes why the figure is important. Present information in the figure and legend as if this were all the reader would see for this point.
- Discriminate what data you present by using only the data relevant to the conclusions drawn from the study.
- However this does not mean that you will intentionally disregard conflicting data. (Please maintain high ethical standards in your scientific endeavors).
- Present only representative data not endless repetitions of the same data. Keep the presentations concise and make the reading of your data as pleasant as possible. Interest fades quickly if the reader has to work hard to figure out what is being presented or why.
- Choosing a method for clear presentation of your data depends on the type of information.
 - If one or only a few determinations or differences are presented it is best to use only text.
 - Repetitive measurements may be presented in tables or graphs.
 - Always consider describing the results in text and *if* the text version is too complex or cumbersome then a table or graph may be warranted.

Avoid redundancy when stating summary of data in text that is presented in tabular form.

Clarity in the Results is paramount. This is the new information that you are presenting to the scientific community. All the other components of the paper are judged by the Results. The Introduction and the Materials and Methods section tell why and how you got the results and the Discussion tells what the results mean.

Discussion

The Discussion is likely the most difficult section to write and define. Many papers submitted for publication are rejected based on problems with the Discussion. There is no ruler for how long a discussion should be. State your interpretation of the results clearly to lead the reader through your conclusions, then end the paper with a summary of the significance of the study.

- Do NOT simply restate the Results.
- Compare your results and conclusions with published materials. Clearly contrast and compare your interpretations with previous studies and findings.
- Discuss the theoretical implications of your work and practical applications that you foresee. Be careful to keep your theoretical projections in proportion to the scope of your work.
- Leave most of the speculation to the readers.
- Present the interpretation of your findings as clearly as possible. Present a summary of evidence for each major finding.
- Make succinct concluding statements at the end of the discussion.
- These conclusions may be what people remember most about your study.

Summary (Abstract)

The Summary/Abstract is a concise, complete report of a scientific investigation that "stands alone" without further explanation. The summary/abstract is typically ONE paragraph with 200 to 250 words. Lengthy discussions and references to the literature are omitted from the summary/abstract.

The summary/abstract must include: basic justification for conducting the study, research objectives, basic methods used, specific results and major conclusions.

These are cited in text by number rather than author and date.

References may be in the following styles:**A) For journal articles**

Aberger F, Costa-Pereira AP, Schlaak JF, Williams TM, O'Shaughnessy RF, Hollaus G, Kerr IM, and Frischauf AM. Analysis of gene expression using high-density and IFN gamma-specific low-density cDNA arrays. *Genomics* 77: 50-57, 2001.

B) For textbook chapters

Sambrook, J., Fritsch, E. F., and Maniatis, T. (1989) *Molecular Cloning: A Laboratory Manual*, 2nd Ed., Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.

Why Papers are rejected from Publications

- The study did not address an important scientific issue.
- The study was not original (someone else had already done the same or a similar study).
- The study did not actually test the authors hypothesis.
- A different type of study should have been done.
- Practical difficulties (in recruiting subjects, for example) led the authors to compromise on the original study protocol.
- The sample size was too small.
- The study was uncontrolled or inadequately controlled.
- The statistical analysis was incorrect or inappropriate.
- The authors drew unjustified conclusions from their data.
- There is a significant conflict of interest (one of the authors, or a sponsor, might benefit financially from the publication of the paper and insufficient safeguards were seen to be in place to guard against bias).
- The paper is so badly written that it is incomprehensible.

Additional Notes

You may like to add an acknowledgement or you may surely like to disclose any conflict of interest that may if not disclosed, cast a shadow on your credibility.

References

1. Davis M. *Scientific Papers and Presentations*, Academic Press, San Diego, CA. 1997.
2. Day R. *How to Write and Publish a Scientific Paper*, 4th Edition, Oryx Press, Phoenix, AZ. 1994.
3. Mc Millan V. *Writing Papers in the Biological Sciences*, 3rd Edition, Bedford/St. Martin's, Boston, MA. 2001.