Guidelines for Writing a Scientific Manuscript

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Writing an effective scientific paper is not easy. A good rule of thumb is to write as if your paper will be read by a person who knows about the field in general but does not already know what you did. Before you write a scientific paper read some scientific papers that have been written in the format of the paper you plan to use. In addition to the science, pay attention to the writing style and format.

Title More people will read the title than any other part of your publication. The title will be reproduced in the table of contents. It will be used by librarians and by most abstracting services. Readers use the title to decide whether to read further.

Titles should:

- Describe contents clearly and precisely, so that readers can decide whether to read the report
- Provide key words for indexing

Titles should NOT:

- Include wasted words such as "studies on," "an investigation of"
- Use abbreviations and jargon

Abstract: An abstract is a succinct summary of the entire paper. The abstract should briefly describe the question posed in the paper, the methods used to answer this question the results obtained, and the conclusions. It should be possible to determine the major points of a paper by reading the abstract. Recent surveys indicate that more than 80% of researchers only ever read abstracts. Although it is located at the beginning of the paper, it is easiest to write the abstract after the paper is completed. Find out the journal's maximum length (may vary from 50 to 300+ words).

Guidelines for an effective abstract:

- State the main objectives. (What did you investigate? Why?)
- Describe the methods. (What did you do?)
- Summarize the most important results. (What did you find out?)
- State major conclusions and significance. (What do your results mean? So what?)

Introduction: The purpose of the introduction is to lead the reader into your work so that by the time you discuss your activities the reader can understand what you are doing and why. The Introduction should (i) describe the question tested by the experiments described in the paper, (ii) explain why this is an interesting or important question, (iii) describe the approach used in sufficient detail that a reader who is not familiar with the technique will understand what was done and why, and (iv) briefly mention the conclusion of the paper.

Guidelines for an effective introduction:

- **Describe** the problem investigated.
- **Summarize** relevant research to provide context, key terms, and concepts so your reader can understand the experiment.

- **Review** relevant research to provide rationale. (What conflict or unanswered question, untested population, untried method in existing research does your experiment address? What findings of others are you challenging or extending?)
- Briefly **describe** your *experiment*: *hypothesis*(es), *research question*(s); general experimental *design* or *method*; *justification of method* if alternatives exist.

Materials and Methods: The Materials and Methods section should succinctly describe what was actually done. It should include description of the techniques used so someone could figure out what experiments were actually done. The details of a published protocol do not need to be reproduced in the text but an appropriate reference should be cited – e.g., simply indicate "were done as described by Hughes et al. (4)". It is important to maintain brevity in this section and remember that your audience is your peers, not someone with no scientific knowledge. Write with your audience in mind. Remember to include descriptions of relevant and essential details of the progress of work, problems and experiences in data collection and processing, particularly where problems have occurred.

Guidelines for an effective methods section:

- Briefly **explain** the general type of scientific procedure you used.
- **Describe** what materials, subjects, and equipment (chemicals, experimental animals, apparatus, etc.) you used.
- **Explain** the steps you took in your experiment.
  Additional tips:
  - **Provide enough detail for replication.** For a journal article, include, for example, genus, species, strain of organisms; their source, living conditions, and care; and sources (manufacturer, location) of chemicals and apparatus.
  - **Order** procedures chronologically or by type of procedure (subheaded) and chronologically within type.
  - **Use past tense** to describe *what you did*.
  - **Quantify** when possible: concentrations, measurements, amounts (all metric); times (24-hour clock); temperatures (centigrade)

Results: The important point to be aware of in this section is that results should be succinctly described but not assessed and discussed yet. The text should contain adequate reference to tables and figures that contain all information, including statistical parameters, required to support the stated results as well as inform and convince the reader, but not more. Any results that include multiple data points that are critical for the reader to evaluate the experiment should be shown in tables or figures. However, the results should be summarized in accompanying text. Not all results deserve a separate table or figure. As a rule of thumb, if there are only a few numerical results or a simple conclusion describe the results in the text instead of in a table or figure. Do not be tempted to report all your results and analysis. If you include unnecessary data, tables and analysis it will appear that you are not focusing on the main theme of your research. Refer back to your key statement and consider which results are needed to justify your conclusions.

Guidelines for an effective results section:

- **Briefly describe experiment** without detail of Methods section (a sentence or two).
- **Report main result(s)**, supported by selected data:
  - **Representative:** most common
  - **Best Case:** best example of ideal or exception

  Additional tips:
  - **Order** multiple results logically:
    - from most to least important
    - from simple to complex
    - organ by organ; chemical class by chemical class
  - **Use past tense** to describe *what happened.*

Tables and Figures: All tables and figures should be put into a contextual framework in the corresponding text. For example, a table of strains used should be mentioned in the Materials and Methods section, a table of results should be summarized in the Results section, a figure showing a biosynthetic pathway should be described in the Discussion section, etc. Tables and figures should present information in a format that is easily evaluated by the reader. It should be possible to figure out the meaning of a Table or Figure without referring to the text.

Tables and figures should summarize results, not present large amounts of raw data. When possible, the results should provide some way of evaluating the reproducibility or statistical significance of any numbers presented.

Tables should be sequentially numbered. Each table should have a title that describes the point of the table. For example, “Table 1. Bacterial strains and plasmids used in this study.” If necessary to interpret the table, specific descriptions about what a result represents or how the results were obtained can be described in a legend below the table.

Figures should be sequentially numbered. Each figure should have a title that describes the point of the table. For example, “Figure 1. Isolation of MudJ insertion mutants.” If necessary to interpret the figure, specific descriptions about what a result represents or how the results were obtained can be described immediately following the title.

Discussion: In this section the results should be critically analysed, compared and discussed in relation to the originally stated problem, hypotheses, and methods. The results are usually contributing new knowledge which should be compared with the previous knowledge. The critical comparison may vindicate the results, but also reveal deficiencies and contradictions, which is scientifically of equal value. The critical discussion and evaluation of any accord, contradiction or knowledge gap and the assessment of their relevance and probable consequences for the science and art of environmental management is an indispensable step before proceeding to the Conclusion.

Guidelines for an effective discussion section:

- **Summarize** the most important findings at the beginning.

For **each** major result:

- **Describe** the patterns, principles, relationships your results show.
- **Explain** how your results relate to expectations and to literature cited in your Introduction. Do they agree, contradict, or are they exceptions to the rule?
- **Explain** plausibly any agreements, contradictions, or exceptions.

Describe what additional research might resolve contradictions or explain exceptions.

- **Suggest** the theoretical implications of your results.
- **Suggest** practical applications of your results?
- **Extend** your findings to other situations or other species.
- **Give** the big picture: do your findings help us understand a broader topic?

Additional tips:

- **Move from specific to general:** your finding(s) **-->** literature, theory, practice.
- **Don't ignore or bury the major issue.** Did the study achieve the goal (resolve the problem, answer the question, support the hypothesis) presented in the Introduction?
- **Make explanations complete.**
  - Give evidence for each conclusion.
  - Discuss possible reasons for expected and unexpected findings.

Conclusion: This section gives a precise and summarizing statement of the results. In addition, if appropriate, proposals for further research are made. The conclusion should begin with a clear statement of the principal findings. But make sure you are brief and stick to the point. Your findings might appear important and significant to you but you need to prove to the reader, and the scientific community, that they are worthy of note. This means setting them in context of previous work. If you are a scientist worthy of publishing then you should know your subject and be able to describe your research within it. That means discussing your outputs in relation to relevant literature. What do your results mean when compared with others?

Citations: It is essential to credit published papers for work mentioned in your manuscript. There are a variety of ways of citing references in the text – the style used depends upon the policy of the journal.

Reference lists: Like citations, a variety of reference formats are used by different journals. For an example of a commonly used example, see “Instructions to authors” on ASM web site (http://jb.asm.org/misc/ifora.shtml) or examples from published manuscripts.

Format: Certain general rules are commonly followed in scientific writing.
Flow. Readers interpret prose more easily when it flows smoothly, from background to rationale to conclusion. Don’t force the reader to figure out your logic – clearly state the rational. In addition, it is much easier on the reader if you explicitly state the logic behind any transitions from one idea to another.

Abbreviations. Use standard abbreviations (hr, min, sec, etc) instead of writing complete words. Define all abbreviations (other than those that are commonly known) the first time they are used, then subsequently use the abbreviation [e.g. Ampicillin resistant (AmpR)]. As a general rule, do not use an abbreviation unless a term is used at least three times in the manuscript. With two exceptions (the degree symbol and percent

symbol), a space should be left between numbers and the accompanying unit.

Past, present, and future tense. Results described in your paper should be described in past tense (you've done these experiments, but your results are not yet accepted "facts"). Results from published papers should be described in the present tense (based upon the assumption that published results are "facts"). Only experiments that you plan to do in the future should be described in the future tense.

Third vs first person. It is OK to use first person in scientific writing, but it should be used sparingly – reserve the use of first person for things that you want to emphasize that "you" uniquely did (i.e. not things that many others have done as well). Most text should be written in the third person to avoid sounding like an autobiographical account penned by a narcissistic author. However, it is better to say "It is possible to .." than to say "One could ...". Writing that uses the impersonal pronoun "one" often seems noncommittal and dry. In addition, inanimate objects (like genes, proteins, etc) should be described in third person, not with anthropomorphic or possessive terms (e.g., instead of saying "its *att* site", say "the chromosomal *att* site").

Empty phrases. Avoid using phrases that do not contribute to understanding. For example, the following phrases could be shortened (or completely deleted) without altering the meaning of a sentence: "the fact that ..." (delete); "In order to ..." (shorten to simply "To ..."). Likewise, the title of a table of results does not benefit from the preface "Results of ...". In short, don't use more words than you need to make your point.

Specify. If several expressions modify the same word, they should be arranged so that it is explicit which word they modify. It is common to use a pronoun such as "it" or "they" to refer to a concept from the previous sentence. This is OK as long as there is only one concept that "it" or "they" means. However, if there are more than one concepts it is easy for the reader to get confused about what the pronoun is meant to specify (even if you know which one you mean). It is better to error on the side of redundancy by repeating the concept in subsequent sentences, than to take the chance of confusing the reader. Don't make the reader guess what you mean.

Parentheses. Avoid double parentheses. For example, "Three gene products catalyze reactions in the pathway for proline biosynthesis (Figure 1) (3)" could be reworded to say "Figure 1 shows the three reactions of the pathway for proline biosynthesis (3)."

Proofreading: Always spellcheck your paper and carefully proofread your paper before submission. In addition to checking for errors and typos, read your paper to yourself as if you were reading it out loud to ensure that the wording and sentence construction is not clumsy.