Notes on Writing a Scientific Manuscript

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This document is not intended to be a complete guide for writing a scientific manuscript. There are plenty of those, and you should definitely read them. Here I list a few common issues I’ve seen (and written myself), and list some hints/tips/strategies for producing a high-quality manuscript.

A well-written manuscript greatly facilitates getting published because it clearly and concisely conveys the research project to the reviewer/reader. Reviewers and readers often have two challenges: understanding the research methods and navigating the writing. You can aid reviewers/readers by communicating your project in the best way possible; doing so will increase your chances of acceptance as well as the impact your work will have.

I. Strategies for writing

* Write from an outline: start with the sections of a manuscript, then list 3-5 ideas per section, then within each section, list the ideas you want to cover.
* Consider a formula/recipe for what should be covered in each section. That will tell you what you need to consider and include and tell you when you are finished. See below for suggestions.
* Start by deciding on your most important points of your project. Imagine what 3-5 points you want readers to take away from your project. What items will you include in your last slide of a talk on this research? These points should be listed in the abstract and conclusions. Write your manuscript to support these points.
* My preference is to get the tables and figures “right”, meaning choose these to illustrate the most important points of your manuscript. Begin by creating a portfolio of figures/tables, then select the critical 4-8ish tables and figures that tell your story and support your most important points. Other figures could be included in a manuscript appendix (often called “Supplementary Information” or similar). The remaining figures should be included as an appendix to your dissertation/thesis/analysis, but these are not important enough to warrant inclusion in a submission to a journal. I will assist you with these decisions.
* Two types of figures are particularly important (see me for examples):
	+ a work-flow diagram, which allows a reader to quickly grasp the data sets in the project and how you used them;
	+ a summary diagram, or conceptual diagram, that summarizes your research; I have found that readers like these, even if what is presented is highly summarized and brief; when considering whether and how to include such a figure, imagine how a professor would use your results in one slide in his/her class, or how another scientist will use your results in one slide in the introduction to his/her talk
* The methods will be easiest to write; you may want to get started while you are still finalizing your analysis. The results will also be easy after you choose your most important points. The abstract, introduction, discussion, and conclusions sections will be harder. If you have a thesis/dissertation proposal, that document has good material for your introduction.
* “Park on the downhill slope” or “stop before you are ready”: this strategy suggests that you stop at a place that makes it easy to get started again; don’t stop when you are stuck or in a difficult place.
* Write a little a day: take the first hour in a day to do some writing, especially when you are having trouble with motivation. Don’t force yourself to write for 10 hours for several days running, then take a weeklong break because you burned yourself out.
* Start early. Write some of your introduction and methods. Add results as they come in. Writing helps you organize your thoughts and may lead to insights as you are analyzing your results.
* Get the thoughts right first (i.e., write down what you want to say), then get the words right (wordsmith).
* Plan on multiple iterations and plenty of lead time before, for example, a defense.
* Take advantage of reviews by other lab members, and be willing to review others’ manuscripts. I became a much better writer after reviewing lots of manuscripts.
* Read the author guidelines for the target journal. This will help you remember writing guidelines, and also these guidelines define the order of your manuscript (which sections are where) as well as number of words in the abstract, etc.

After I return my comments to you, for each of my comments/suggestions, either include/adopt it or tell me why you don’t want to (which is okay). If you do neither, I’ll assume you missed that comment and will repeat it.

For major comments, please copy/summarize in a separate document and respond in a separate font (similar to responding to a manuscript review).

* As you get closer to a final version, please provide a change document created with Word Track Changes in addition to the updated version. This will allow me (and other coauthors) to see the only things that changed and to focus on these areas.

II. Organization and structure

A. Manuscript-level organization

* You should write for readers at three different levels. Here is text from JGR Biogeoscience:

1. Skimmed (abstract and figures only; abstract, figures, and some captions and tables; conclusions and implications section)

2. Examined in a more through manner (abstract, introduction, figures and captions and tables, and some text of results and discussion section)

3. Read carefully from beginning to end, typically as part of planning follow-up research or for citation in paper the scientist is writing.

These comments suggest including some interpretation within figure captions (and table legends?).

* Create a “document map” in Word by changing the outline levels of sections and subsections (Format Paragraph/change outline level); turn this on by showing the document map; include tables and figures; keep this clean and updated. This Word document includes a map. This will be a way of writing to an outline, especially when you include the subsections. It is also an excellent way to navigate the manuscript, especially for me and other reviewers.
* Number all pages including the title page (may depend on journal).
* Add line numbers to all pages from the abstract through the text, references, and figure captions; do not add line numbers to tables or figures (too messy, unneeded).
* Numbered sections and subsections (e.g., “1.2.1 Climate data sets”) are great clues for readers about manuscript organization and hierarchy (providing context).

Notes on Sections

Other sources go through the content of sections; see them for details. Here are a few notes.

1. Abstract

* Abstracts should be a short synopsis of your paper: What is the purpose of the study? What were your methods? What were your results? Why are your results important (implications)?

2. Introduction

* Use the funnel method: start broad, narrowing the focus as the introduction proceeds so that you end up describing your study.
* When describing past studies and the state of knowledge about your topic (as in the Introduction), write sentences that make statements about the science, not about a study. For instance, write “Drought is a major influence on outbreaks of mountain pine beetle (Columbus 1492)”, not “Columbus (1492) found that drought …” See later comment about the Discussion section.
* End the introduction section with a paragraph that lists your objectives/hypotheses and a brief summary of your methods (1-2 sentences); in the paragraph before, describe the gap in scientific knowledge that you are filling; see Bentz et al., 2010, BioScience for an example.

3. Methods

4. Results

* On combining the Results and Discussion section: this quote from JGR Biogeosciences makes sense to me: “…a combined Results and Discussion section can impede skimming the paper and reading the paper at an intermediate level of thoroughness.”
* Crystal Kolden suggests that the appearance of citations in the Results section is a clue that perhaps that text should be moved to the Discussion.

5. Discussion

* In conjunction with the Conclusions, the Discussion section should move from the specific (your study) to the most general (implications for scientific knowledge) (note that this is opposite to the Introduction).
* In my view (others have other views), a Discussion section should have three parts:
	+ Restate your most important results. Identify your top 5ish ideas (the ones you’ll discuss in the Abstract plus maybe 1-2 others as appropriate) and restate them here together with interpretation. Be brief; don’t restate every idea presented in your Results.
		- If you are including specific numbers in your Discussion (“trends were 5.5 m/year”), that may be a clue that you are too specific; such text probably belongs in the Results, and may indicate that you are not “discussing” your results (describing general findings).
	+ Discuss caveats, assumptions. Be clear and honest about your methods, and what the implications of holes/uncertainties could be.
	+ Compare your results with those of other studies. Here, talk about individual studies and their methods, and how they compare to yours. Reverse the emphasis of study and finding from the Introduction; for example, sentences could be constructed as “Smith et al. (2010) found that trees are made of jelly, which is similar to our findings.”

5. Conclusions

* Conclusions should be broad, sweeping statements about the implications of your results for the broader scientific and management community. You don’t want to be specific about numbers/results here, but rather generalize. What will you tell your graduate student friend in chemistry (or better, in business) or your mother?

I prefer a separate Conclusions section because it warns the reader what is coming and provides a better opportunity for readers to skim. If you have the conclusions buried in the Discussion, the reader has to work to find them, and when reading through the Discussion, may not realize that s/he is reading the conclusions right away (i.e., s/he will be confused).

6. Acknowledgements

* Please acknowledge the support of all funding sources, including mine and other coauthors.
* Thank friendly reviewers, field/lab personnel, others who helped with discussions, ideas, etc.
* Thank reviewers in subsequent submissions.

7. References

* Follow the guidelines of the journal.

8. Tables

* caption/legend above table
* use “regular” Word tables; minimize fancy stuff like merging cells
* do not use blanks/spaces
* follow journal specs w.r.t. rules (horizontal lines); often the specs are rules surrounding column headers and at bottom
* place after references, before figure captions (or follow journal specs)

9. Figures

* read journal for specifications, including whether to submit as part of the text or as separate files
* color figures look better, but are costly; today, many journals allow color online for free and gray-scale in print; be aware of how color figures look in gray-scale
	+ avoid red-green for color-blind people
	+ ensure colors are well separated
	+ I personally do not like single color gradient ramps; one cannot distinguish many levels; I like rainbow colors, especially if more intuitive (temperature)
* create figures for both manuscripts and for talks; often they are the same, but occasionally manuscript figures are too complex (in which case break down for a talk) or are required to be gray-scale
	+ write figure generation code for both color and gray-scale if needed
* line plots
	+ thick lines
	+ different colors and/or line styles (dashed, dotted) and/or thicknesses
	+ make sure there aren’t too many different lines to read in one figure
* x, y axes
	+ thick lines
	+ labeled correctly, clearly (i.e., not “internal variable names”)
	+ lower case labels
	+ be aware of journal specs w.r.t. inside or outside ticks
* legends for different lines
	+ text colors match colored lines
	+ ideally, labels next to lines or arrow between text, line
* for multipanel figures, each panel has a label (“(a)”, etc.)
* caption
	+ Spell out “Figure”; do not abbreviate to “Fig.”; same in main body of text when you refer to a figure
	+ clear, concise description (not full sentences)
	+ panel label (e.g., “(a)”) before descriptive text
	+ all lines, colors described
	+ some interpretation is appropriate
	+ duplicate captions: a) journals want captions as separate text before figures (but do this late in the manuscript preparation); b) also put captions below figures for easy of reading/review. As a reviewer, I prefer to see figure captions on the same page as the figures. This allows me to avoid flipping back and forth between the figure and its caption on a separate page. Thus, I prefer to do this in my manuscripts because it helps reviewers. Journals usually require figure captions to be on a separate page from the figures (probably to allow copy-editing after the manuscript is accepted), so copy the text from there to the figure pages. Make sure any updates are added to both places.
* figure created at appropriate size (full page? half page?) and pixel resolution (300 dpi)
* figure format follows journal specs (e.g., “PS”; not screen shot)
* be careful with Powerpoint as it doesn’t have high resolution (72 dpi???)
* in manuscript, one figure per page for clarity and to allow for comments; insert page breaks, not multiple carriage returns

B. Paragraph-level organization

* this level was hardest for me to learn
* start with a topic sentence that introduces the reader to the ideas in the paragraph
* break very different ideas into different paragraphs
* avoid burying an important idea in the middle or end of a paragraph

C. Sentence/word-level organization (grammar and syntax)

* break long sentences containing multiple ideas into two sentences
* adverbs ending in “ly” are not hyphenated
* verb tense is usually past; you describe in the manuscript what you did; exceptions include when present tense is used to describe the state of knowledge (“climate change affects skin warts (Smith et al.)”, but “Jones et al. found that climate change affects ear wax”)
* consider eliminating unneeded “the’s” by reading a phrase without the “the”
* refer to figures parenthetically, and don’t describe what the figures are in the text (a reader can see that Figure 1 is a scatter plot of temperature and precipitation, for example); say “Temperature is related to precipitation (Figure 1)”, not “Figure 1 shows temperature versus precipitation, and it can be seen that temperature is related to precipitation”
* spell out all acronyms in tables and figures
* do not include “Figure of…” in figure caption; similar for tables. Readers already know it is a figure or table.
* be careful with commas. Read up on comma use. A good test is to read the sentence aloud; insert a comma when you pause, and remove all other commas. Fewer is often better.
* avoid hanging/solitary “this”, “that”, “these”, “those” (e.g., “This means that climate change…”; “this” what?). Add a word following these words to be specific about what the “this” refers to.
* some people don’t like having multiple adjectives describing a term, also known as “noun stringing,” “stacked modifiers,” “noun stacking,” or “freight-training”. For example, avoid/break up “widespread climate-driven mountain pine beetle outbreaks.”
* hyphenating prefixes: “Do not hyphenate words prefixed by non, un, in, dis, co, anti, hyper, pre, re, post, out, bi, counter, de, semi, mis, mega, micro, inter, over, and under (among others).” (<http://www.grammarmudge.cityslide.com/articles/article/426348/2805.htm>)
* in lists with >two elements, all but last element are followed by commas: “Bill, Frank, and Steve”, not “Bill, Frank and Steve”
* “e.g.” and “i.e.” are always followed by commas unless the journal specifies otherwise
* read up on “that” versus “which”; briefly and generally, use “which” following a comma or parenthesis
* avoid acronyms that many readers are not familiar with, such as MPB for mountain pine beetle
* use “sentence case” for capitalization of section headings; consider sentence or lower case for table entries (but not title case)

III. To-do list just before submitting

* carefully reread for text flow, missing words, etc.
* rerun Endnote/similar bibliography software as appropriate
* use spelling/grammar checker in Word
* print out figures to ensure they are at appropriate resolution (not fuzzy); also check color if appropriate
* persevere! the last reading will be boring and difficult, and motivating to read it will be a challenge. However, it shouldn’t take more than 1-2 hours. Set up a reward for yourself after you finish as a motivational tool.

IV. Other Resources

WWW

Boice, R.: “Advice for New Faculty Members”

Gustavii, Bjorn: “How to Write and Illustrate a Scientific Paper”

Katz, M.: “Elements of the Scientific Paper”

Day, R.: “How to Write and Publish a Scientific Paper”

Boler, J.: “Writing Your Dissertation in Fifteen Minutes a Day: A Guide to Starting, Revising, and Finishing Your Doctoral Thesis”