THE ART OF WRITING SCIENTIFIC PAPERS AND PROPOSALS

Cin-Ty Lee

Scientific writing is a form of logical communication and thinking. Good scientists are always strong writers. Strong writing skills help to develop good speaking and teaching skills. Weak writing skills are often symptomatic of inadequate experience in thinking scientifically and of the lack of knowledge.

What makes a good writer?

1. Knowledge of the subject or topic.
2. Passion for the subject.
3. A logical and creative mind.
4. A desire to communicate.
5. Appreciation for who the audience is.
6. A willingness to revise and rewrite.

Note that nowhere is the mastery of the English language or grammar mentioned. Good writing can be done in any language. Poor English is not an excuse for poor writing abilities. It also does not follow that native English speakers are naturally better writers. This class will be about communicating in the written language. Elements of English grammar and style are second-order issues, which can be easily learned or corrected with due diligence.

Your written work should be treated as <u>your</u> artwork

Writing is a form of creative expression, and therefore writing, even scientific writing, is a form of art. In art, one's creative works are his/her masterpieces. The necessary ingredients for making a good writer are the same for making a good artist. The artist has command over his painting. Similarly, the writer should have complete command over his/her manuscript, even if the contents of the manuscript result from collaborations with other authors. If you understand this analogy with art, then it becomes clear that, as an author, you would never copy someone else's work (plagiarism) and you would not let someone else (such as your advisor) write the paper for you and still put your name as first author.

Scientific writing is like the story-telling of solving mysteries

There are four components of science. The first is recognizing good questions or problems. The second is answering these questions by systematic experiments and observations. The third is interpreting the experimental results. The fourth is communicating the results and implications to the outside world for the benefit of society. A scientist is therefore very much like a modern-day Sherlock Holmes. We are detectives. We have a responsibility to tell the story of how we solved our mysteries. Good detective stories follow this basic template:

1. Set the scene and identify the mystery or problem to be solved.
2. Describe the methods used to gather data (evidence).
3. Present the data (evidence) in an unbiased way (negative, positive and neutral data must all be presented).
4. Analyze the data
5. Interpret and discuss the data
6. Conclude

If any of these elements are missing or adulterated, then the credibility of the story is jeopardized.

Structuring a scientific paper

There is only one template for writing a scientific paper. Deviating from this template can be perilous unless you are highly experienced at writing. The general template parallels that of the above detective story. A cardinal rule is that all elements of the paper must flow continuously and uni-directionally. In this regard, scientific papers differ fundamentally from fiction novels, essays or movie scripts, which are often littered with flashbacks, flash-forwards, and continuous suspense. Scientific writing should be direct and concise with minimal suspense, except for a little anticipatory suspense in the introduction. Above all, scientific writing needs to be clear, leaving no room for interpretation of the author's thoughts (the author's interpretations may eventually turn out to be wrong, but there should be no question about the author's ideas or views).

Here are the basic structure and order of a scientific paper. Follow it religiously.

Sections within the body of the manuscript

1. **Introduction**

   This is where you motivate the reader by clearly identifying the question or problem and explaining their broader significance. This is also where you provide necessary background information for the reader to appreciate the importance of the problem. Then you briefly present your analytical approach or philosophical approach to solving the problem. This section should be concluded with a brief taste ("appetizer") of what is to come in the rest of the paper to seduce the reader into reading beyond this section. This section should be written for the non-specialist. Keep jargon to a minimum.

2. **Methods**

   This section establishes the credibility of your data and results. This is where you present the details of the analytical methods, experimental setup, or numerical setup of your study.

3. **Results or data**

   This is where the evidence and the observations are presented in an **unbiased** way. All the results of the experiments, whether positive or negative, must be presented without interpretation. The data should stand the test of time, so do not dirty it with your opinions, biases, interpretations, etc. This section should be clean and simple. Just provide the facts. Note that this is the section where you can discuss the quality of the data or show correlations. You can also compare your results with other published results, but again, refrain from interpretation. Keep in mind that everything you present in this section must be addressed in the Discussion or data analysis section (i.e., don't generate orphans).

4. Discussion and data analysis

In this section, you present what you think the data mean and how you arrived at your conclusions. This is where you interpret the data, discuss implications, and extrapolate. This is where you return to the objectives and questions laid out in the introduction. Remember, in the Introduction, you made a promise to the reader that you were going to deliver. Now deliver. How do your data help to address the hypothesis or question you asked in the Introduction? How do your results and your interpretations compare to other published studies? Be fair and honest. Lay out the logic of your conclusions. Point out the limitations of your interpretations.

5. Conclusions

This is the final delivery. Here, you re-iterate the most important messages in your paper. You do not need to motivate the problem in this section as you must assume that the reader has already read the introduction. Similarly, it is not necessary to discuss the Methods or how one arrived at the conclusions. All one needs to do here is to summarize the most important results (data) and the most important conclusions derived from the data.

Frontspieces

A. Title

The title must be a concise and informative phrase. This is the first thing a potential reader will see.

B. Abstract

An abstract is generally one paragraph that summarizes the entire paper. The order and organization of the sentences should be structured like the main sections in the manuscript. The first couple sentences must motivate the problem (e.g., introductory sentence), followed by a couple sentences describing the methods (establishing credibility), then several sentences summarizing the most important results, and ending with several sentences presenting the preferred interpretations and conclusions of the paper. What should not be in the abstract are the elements of the Discussion section. Wild speculations should also not be in this section. The purpose of the abstract is to tell the reader what the problem is, how it was done, and what was found. It should not be a discussion.

Some additional tips for writing good scientific papers

Harmony

Build-up: A good introduction advertises, motivates, and entices the reader to continue reading by giving the reader hints of what is to come.

Follow-through and delivery: After building-up the expectations of a reader, you need to follow-through and deliver with data and conclusions.

Balance between promise and delivery: The build-up and follow-through must be commensurate. If your build-up is too strong and you have no delivery, your paper falls flat and nobody will ever read a paper authored by you again. If your build-up is too weak, then you've undersold your work. Above all, never try to amplify your conclusions with shameless speculations just to satisfy your promise. If your results are not as stunning as you expected, tone down your introduction.

Simplicity

Good scientific manuscripts should have only one or two main messages. Smaller messages are still important, but must be relegated to their appropriate hierarchical positions. More than two big messages will confuse the reader.

Creatures of habit

When writing your paper, think about your audience. When most people pick up a paper, the first thing they look at is the title. Is the title interesting and informative? If so, the reader will either go straight to the introduction or the abstract. Experts in the field will likely read the abstract first, but non-experts almost always go to the Introduction because they are curious what type of scientific problem is being solved. This is the turning point for your reader. If you lose him/her here, it's over. However, if you're successful at maintaining his/her interest, the reader will likely then skip right to the Conclusions to get the punchline of your story. If he/she finds the punchline interesting, then he will take the time to wade through the details of your methods, results and discussion. He will then take your abstract as a memento of your paper since it is humanly impossible for him to remember all the details.

Outlines and flowcharts