# Lecture Notes: Writing content

Scientific writing should always follow the following outline:

1. Introduction

2. Methods

3. Results

4. Conclusion

All papers and reports should have sections with these titles. There can be subsections with other titles, but there should not be any other main sections. However, this writing style is so powerful that it is useful for many other types of writing. Professional writing, technical writing, business reports, and many other documents can and should follow the same general outline. In fact, I would go so far as to say that all writing, other than for entertainment, should follow this outline. If you are ever tasked with writing a document and you do not know how to approach it, follow this outline and you cannot go wrong.

The trick is to realize that each section answers a specific question:

1. What is the problem?

2. How do you propose to solve the problem?

3. What were the results of trying your method?

4. What did you learn?

Everything written in each section should be part of the answer to these questions. These questions are useful for just about any type of writing.

For example, consider the introduction and the first question it asks: "What is the problem?" This is the most important question addressed by any document. As an author, you are trying to grab the attention of the reader and convince them as to why they are reading your writing. A good first sentence often starts "This paper/article/report considers the problem of ...". In that one sentence, you want to tell the reader why they should care about reading the rest of your paper. Everyone has limited attention and time, and so making this sentence clear and succinct is critical. Nobody wants to read a whole page before figuring out why they are reading your document. This is equally true of business reports and scientific papers.

Figure 1: In the Peanuts comic strip, Snoopy starts to write.

"It was a dark and stormy night ..." In the comic strip Peanuts, a running gag consisted of Snoopy writing this line every time he started a story. The punchline often involved figuring out what to write next. The feeling of not knowing what to write next is so common it has a name: "writer's block". The trick is to always write in a such a way that you are answering a question. Besides the obvious high-level questions given above, every sentence you write raises additional follow-up questions. Subsequent sentences should expand upon the additional questions that are naturally raised by answering the previous question. For example, suppose the first sentence reads "This paper considers the problem of model fitting." This raises some natural next questions, "What is a model?" and "What is fitting?" Therefore the next sentence should answer one of those questions. For example, "A model refers to a mathematical equation that can describe the general shape or pattern of a set of data. Fitting refers to finding the best parameters for the model for a particular set of data." Now another question can be posed, namely, "What does 'best parameters' mean?" This leads to the following next sentence: "The best parameters are the values of unknown variables in the model that best fit the general shape to the given data." This process of answering questions raised by each sentence continues until the first question is sufficiently answered. In the case of the first paragraph, the reader should have a pretty clear idea of "what is the problem".

The introduction should answer the following questions:

(a) What is the problem?

(b) Why is it a problem?

(c) How have other people tried to solve the problem?

(d) How do you propose to solve it?

Each of these questions should be answered by a separate paragraph. Immediately after establishing the purpose for writing the document (the answer to "what is the problem"),
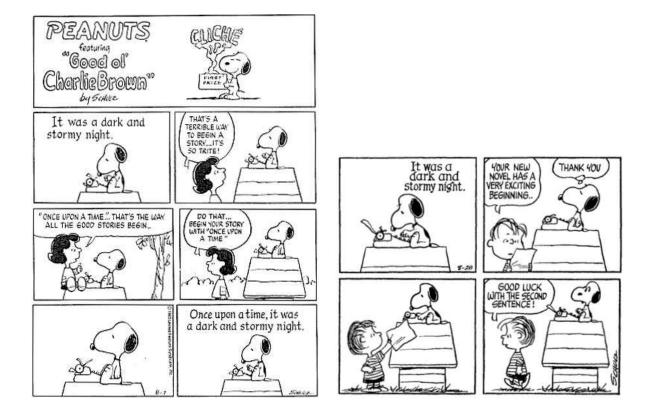
Figure 2: Punchlines about Snoopy not knowing what to write next.

the author should explain the circumstances of why or when the problem occurs. Examples can be very helpful. This paragraph can give statistics about the problem, or supporting information describing the scope of the problem. In a very long document, the answer to this question sometimes gets its own subsection entitled "Background". This is especially useful if one or more side issues needs to be explained in order to provide full context for the work.

The next question concerns how other people have tried to solve the problem. Presumably you are not the first to realize this problem needs work! This paragraph is where you provide the reader with a synopsis of current events. It may describe techniques taken by other professionals, or it may describe competitor products. In a scientific paper or thesis, the answer to this question may be given its own subsection entitled "Related work".

The final question in the introduction concerns what you intend to try. In the case of a scientific paper, this is where you make a case for your novelty. In the case of a business plan, this is where you make a case for how your new business will differ from those in the surrounding area. In the case of a market analysis, this is where you make a case for a product niche or how your product will differ from its competitors. At this point, the reader should have a clear idea of the purpose of the entire document.

The methods section of the document is all about the details. It should provide the reader with everything they need to be able to fully understand your work. In the case of a scientific paper, the reader should be able to duplicate your experiment. This is the heart and soul of the scientific method; experiments should be repeatable. If your paper does not provide enough detail for the reader to duplicate your experiment, then it is not written well. However, this idea also applies to business and other documents. The reader should be able to reimplement your plan without having to call you to ask questions; all the details should be contained in the methods section.

A good way to approach writing the methods section is to overview the entire approach. A high-level diagram or flowchart or algorithm is useful. It should provide a snapshot of how the entire new thing will work, whether it is an experiment, business or new product. The description of this diagram should take a whole paragraph. Subsequent paragraphs should then zoom into single pieces of the diagram, providing greater detail. Each paragraph should provide enough details about the piece of the whole product (or system or business) as to enable the reader to duplicate your effort. Whenever you find yourself stuck on what to write, ask yourself the following question: "Do the methods written provide enough information to recreate my results?"

The results section provides data. It should consist primarily of tables, figures, measurements and calculations. It should be objective; this is not the section in which you provide your opinions (that comes later). However, you must *interpret* the data for the reader. A big mistake naive writers make is to provide a "data dump" without helping the reader understand the results. The reader does not want to read through large tables to discover the two entries that are significant. The reader does not want to study a graph to learn that part of one plot shows an increasing trend. These points are things that the writer needs to highlight. Similarly, if a table or graph does not contain any meaningful highlights, it probably does not belong in the paper. It may belong in an appendix, or it may be superfluous and should be deleted to save the reader's time. A good rule of thumb is that every graph or table or result should have a paragraph highlighting the key findings in the data.

The paragraph may be as short as one sentence, or a very long paragraph, depending on the amount of findings.

The conclusions section interprets the results. It often starts by succinctly repeating the *key* findings from the results, stated in language from the introduction, thus tying together the entire work. It should then provide discussion about the results. The discussion should answer any of the following questions that are relevant:

(a) How well did your methods work?

(b) What are the limitations?

(c) From these results, what do you suggest doing next?

Some writers prefer to label this entire section "Discussion" instead of "Conclusion", but the content is the same. This section should tell the reader how well the method worked, but also under what conditions it fell short or failed. Any limitations of how it was tested should also be explained. Finally, given all that you now know about working in this area, what are your impressions of the difficulty of the problem? What parts of the problem remain to be solved? How would you approach the next piece of work in a continuing effort to solve more of the problem? The answers to these questions can be somewhat subjective, because they are based upon your experiences and expertise.

In class, I will demonstrate the organization and writing of several example documents following this paradigm.