Some Guidelines for Writing About Science
The Chemistry Department
Marist College

Writing about science? Science is about hard facts and numbers and calculations. English classes are about writing. I signed up for this course so that I wouldn't have to write at all. WRONG!!! Writing is a big part of science. Scientific discoveries are meaningless unless they can be effectively distributed to the rest of the scientific community. Suppose that in the future, you find the cure for AIDS. A great discovery, no doubt. However, you are content with your discovery and do not bother to tell anyone. No one is cured, the disease still exists, nothing has been accomplished. Suppose that you do publish your results, however, your paper is so poorly written that no one can understand it. Again, nothing accomplished.

The advancement of science depends on the distribution of ideas. Scientists do this by reading and writing journal articles. One of the main goals of laboratory courses at Marist College is to teach you how to write scientific journal articles and thus effectively present your ideas. As a side bonus, the more you know about how science is written, the better you will be able to read and understand scientific literature from journals to your textbooks.

This document is intended to give you an outline of how scientists write about their work. It is intended to be applicable througoht your entire college career and therefore*, some items may not be exactly applicable to your situation in general chemistry*. If in doubt, consult your instructor. The scientific literature is quite extensive. For now we will stick to the American Chemical Society journals because they are leading journals and all readily available on-line from our library. Any journal will do but, "Analytical Chemistry" and "Inorganic Chemistry" are good for the format issues we are dealing with here. Although you will only be required to print out one article, read as many as possible! You may not understand the chemistry but that is o.k. Look at the format and the way ideas are presented and the overall writing style. The more you read the better you write. Not ALL journal articles will follow the guidelines herein. However, for now you should stick to this format. As you begin to master scientific writing, you can modify the format to fit your personal needs. First thing you need to do is find an article:

How to find a journal article

1) First get online from the Marist Library. This will require your k account and password.
2) Go to http://www.marist.edu.
3) Click on the "Library" button and then "Enter the Library".
4) At the top of the page on the "research" pulldown menu choose "databases".
5) Select "ACS Publications"
6) You will be asked for your k account and password again.
7) Click on "journals & magazines" over on the left side of the page.
8) Select any journal. "Analytical Chemistry" and "Inorganic Chemistry" are good places to start.
9) The table of contents of the current issue of the selected journal will be displayed. Pick one of the papers under the "Articles" heading. *Everyone should choose a different article*. DO NOT choose a "communication", "Technical Note", "Revision", "Letter", "Review" etc… as these will have different formats.
10) Click the "Full text –HTML" or "Full text-PDF" in order to display/print your article.
11) If you have problems, ask a librarian.

The Purpose

In order to figure out the purpose of scientific writing you must first ask yourself, "what is the purpose of science?" Science attempts to answer questions, to explain the world around us. There are two main ways that scientists accomplish this:

1) *The hypothesis.* A hypothesis is basically an educated guess. After observing an interesting event in nature, a scientist questions that event and attempts to come up with an explanation based on previous knowledge. This "pre-experiment" explanation is a *hypothesis*. The scientific paper then revolves around this hypothesis: You first introduce the hypothesis to the reader, then you explain the methods you used to test your hypothesis, then you present the results you obtained and discuss how these results prove or disprove your hypothesis

2) *The question.* Sometimes you only have a question that you are trying to answer and a reasonable hypothesis is not possible or applicable. In this case you design your experiment and write your paper in order to answer the question. The idea is the same, you present your question, explain the methods you will use to answer the question, present your results and discuss how your results answer the question. As with the hypothesis, you need to come up with possible answers to your question beforehand. This is the way most advanced scientific papers are written today. In the end, both formats are really the same, a hypothesis is just an attempt to answer the question beforehand. In general chemistry you will stick mostly to the hypothesis format.

Usually, journal articles are divided into 5 parts: *abstract, introduction, results, discussion and conclusions.*

Abstract

Even though the abstract is presented first in the text, *it should be written last*. As mentioned earlier, the chemical literature is VERY extensive. There is no way anyone could read it all. The idea of the abstract is that people can quickly read through it and determine if they want to spend more time reading the entire article. Therefore, the abstract should contain all the main points of the full article in a single small paragraph. The main items that should be in the abstract are:

-The purpose. Briefly state your reason for doing the experiment.

-The general method. Do not go into detail here. Just state general techniques such as "titration" rather than specifics such as "100.0 mL of 1.00 M NaOH were titrated with…"

-The main results. Just the results that are directly related to the purpose.

-The main conclusions.

Introduction

This is where you introduce your hypothesis/question to the reader. It is not enough to simply state the hypothesis/question. You must tell the reader what observation your hypothesis/question is attempting to explain first. You must also get the reader up to speed with the *relevance* and *background* of this particular question. Why is this question important? How will answering it contribute to the scientific field? What is currently known about this question? What work has been done in the past on this subject? What is the theory behind this subject? All of these little questions answer the bigger question of why are you taking the time to do this experiment, why you are doing it in a specific way, and why you think your hypothesis is valid. The main items of the introduction are:

-State the question/objective. What is the question you are trying to answer? What observation are you trying to explain?

-Importance. Why should anyone care about the answer to your question? Include real world applications here. For example, an experiment studying chemical reactions is not just a neat thing to do in the lab. Chemical reactions are taking place all around you all the time. Plants turning sunlight into energy is a chemical reaction. By studying a chemical reaction in the laboratory, you understand more about photosynthesis.

-Previous work. What has been done on this subject in the past? It is not enough to just state previous work. You must also explain how the previous work is related to your objective.

-State the hypothesis if you have one. What is your answer/explanation to the above question? Remember, the hypothesis is a *possible* explanation not a definite answer.

-Rationalize the hypothesis. In other words, based on current scientific knowledge, why have you chosen this hypothesis? Think about and clearly describe possible/expected outcomes. If a definite hypothesis is not applicable, rationalize the importance of your question. Why is it important? Why are you trying to answer it?

-Methods. This is different from the "Materials and Methods" section described below. In the introduction you want to state the general method you have chosen to answer your question (i.e. spectroscopy) and explain why you have chosen this method. For example, suppose you are doing an experiment where you want to find the concentration of an ion in solution by spectroscopy. Why spectroscopy and not titration?

-Theory. Some articles are more theoretically based than others. Therefore, the amount of theory you put into the introduction will vary depending on the emphasis of your particular article. In the above example using spectroscopy to find concentration your emphasis is on the concentration of your sample so you do not have to go into great depth about the theory of spectroscopy. However, if you had a system that

gave a strange spectra and the point of your research was to explain why this spectra is different than expected, you will have to go more in depth with the theory. In either case you will have to cover enough theory in order to explain the basic concepts behind your work. The reader needs enough theory in order to be able to understand your arguments.

-Equations. If you have any specific equations that you will need in completing your objective, they go here. Also, show any derivations of equations that you will need here.

Materials and Methods

This section is sometimes known simply as "Methods" or "Experimental" or "Theoretical Methods". The point of this section is to describe what you did in the laboratory in enough detail so that a scientist reading your article can repeat your experiment and get *exactly the same results*. Repeatability of experiments is an important part of science. Without external verification, there is no way of knowing if your claims are valid. The methods section is a narrative not a cookbook. Do not simply list the steps. Important points include:

-Narrative of the procedure.

-Materials used. You need to tell the reader what chemicals (name, formula, manufacturer, purity) and instruments (manufacturer, model number) you used so that they could verify your experiment by performing it with the same equipment and the same chemicals. Any computer software should be identified by name, manufacturer, version and source.

Results

Sometimes the Results and Discussion section described below are combined into one section. For now, keep them separated until your writing skills have improved. As with the "Methods" section, the "Results" section is a narrative. Do not simply list results. Some results are more clearly presented in tables graphs and figures. All tables graphs and figures should be properly labeled and placed at the end of the article. You can then refer to the tables in your narrative as in "The measured masses can be found in table 1…." The important points of the results section:

-Significant outcomes. You only need to talk about the relevant results. The results that you are going to discuss in the next section. The results that prove or disprove your hypothesis. For example, suppose that your experiment involves a chemical reaction that produces some amount of a specific product. You get the product by filtration and find the mass by weighing the filter paper with product and then subtracting off the mass of the filter paper. The final mass of the product is important and should be in the results section. The mass of the filter paper is irrelevant. (***NOTE: in gen chem sometimes you list all your results so that the instructor can find possible errors. Ask!***)

-Reference to tables graphs and figures. All graphs, tables and figures should be properly labled. Tables should be numbered consecutively and titled above the table. Graphs and figures (both fall into the category "figures") should be numbered consecutively below the figure (separate from table numbering). Each figure should have a figure caption briefly describing the figure. See your journal article for examples.

Discussion

The discussion is the most important section of the paper. This is where it all comes together; where you interpret and explain your results. Was your hypothesis valid? Did you answer the question? Why or why not? You are trying to convince the reader of your position. You are arguing a specific point and you MUST have evidence (your results) to back up your point. Even the most carefully planned experiments designed by the most gifted scientists rarely go as intended. The unexpected is part of the excitement of science. If/when you get results other than expected, you must explain why. ***NOTE: WE ARE MORE CONCERNED WITH HOW YOU EXPLAIN YOUR RESULTS THAN YOUR ACTUAL RESULTS!!!*** Explain any possible errors. Do not lay blame. Do not say that your results are wrong because your lab partner screwed up or because you screwed up. If something went wrong in the measurement, tell HOW you did the measurement and how that would effect the result. For example, suppose you do a filtration and then collect and weigh the solid but your results are way off. When you think about how you did the experiment you remember that you weighed the filter paper after 5 minutes instead of waiting 2 hours. You have identified a possible source of error. This is good, but do not stop there. Explain how that error could effect your results as in, "The drying time was insufficient and

therefore the filter paper contained additional water making the measured mass too high." Important points for the discussion:

-Interpretation of results. What do your results mean? Explain how they are related to the initial question and the hypothesis.

-Validity of hypothesis/question? Is your hypothesis correct? Did you answer the question? Why or why not?

-Sources of error. Do not just state the error, explain it and rationalize it. Describe how the error relates to the hypothesis.

Conclusion

Wrap it all up. You will see some papers that do not include conclusions. For our purposes you should ALWAYS have a conclusion section. In addition to restating the main outcomes of your experiment, you should talk about the broader implications of your work. How do your results contribute to the greater body of scientific knowledge? By answering a particular question, does your work raise more questions? (this is usually the case) Do your results suggest any future experiments?

References

If you used anyone else's work in writing your article you MUST acknowledge their work. There is a definite format to citations which varies depending on the journal. We will use the ACS format. For Journal articles this is:
Last_Name, Initials; Last_Name, Initials;…, *Abreviated Journal_Title*, **year**, *volume*, page.
The format for books is:
Last_Name, Initials; …, *Book_Title*, edition; Publisher: City, year.

Notice the punctuation and italics and bold type above. Look at your printed journal article for examples of the proper citation format. For our purposes always put your references at the end of the text.

General notes

Keep in mind that you are writing in the English language and as a result, your work must conform to the rules of the written language. Proper spelling and grammar are required. Proofread your paper. You would be surprise at how much you pick up. Go to the writing center. They might not understand the science involved but they can help on writing structure. Often it is good to have someone who doesn't know the science to proof read. They will often pick up things a scientist will take for granted and overlook.