An Introduction to Scientific Communication

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One of the most important parts of science is being able to communicate findings to other scientists and the general public.

Whether you are an elementary student making a poster for a science fair, a grad student preparing for your first scientific conference, or anything in between, this document is designed to give you the information you need to communicate your science effectively.

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Parts of a Scientific Report

Whether a scientist is reporting their research by writing a journal article for peer review, giving an oral presentation, or presenting a poster, they will divide their report into the following common main sections:

Abstract

This is a brief, condensed version of the entire report. (Most scientists will read the abstract of a journal article to decide whether they want to read the rest of an article.)

The abstract is frequently referred to as a "mini-paper" because it contains information from all four major portions of the report. For students doing a short (one or two lab periods) experiment, a general guideline is to give a one sentence statement of the problem, one sentence on methods, a one sentence summary of results, and one sentence of what the results mean. Sometimes it's possible even condense this information into two or three sentences.

If you are giving an oral presentation, don't put your abstract in your Powerpoint. If you were actually giving a presentation at a scientific conference the abstract would be printed in the conference program so that attendees could decide which talks they wanted to attend.

Introduction

This section gives background information on why the research is important by placing it in the context of everyday life. It also includes literature review that describes past work that has been done by the field. Finally, the introduction includes the questions that the scientist is/was trying to answer with the study that is being reported.

Methods

This section tells how the scientist did the work. In a written paper this will be done in relatively great detail, but the section is frequently quite abbreviated in oral or poster formats unless the study was specifically testing new or revised methods.

Results

This section summarizes the data collected in an experiment. Results shown here may be raw data (observations collected in the course of the experiment) or processed data (graphs, etc. showing trends; values calculated from raw data).

Discussion

In this section, the scientist explains their interpretation of the data reported in the results section. Part of this section is an evaluation of how good the data is—how precise is the measurement method? How reproducible are the results? Another important part is the explanation of how the findings of the current study fit into what has already been reported by other scientists. Most scientists also spend some time explaining what work could be done in the future. This section usually ends with a concluding paragraph that summarizes the whole report.

Other sections

Other sections frequently found in scientific reports include:

- Acknowledgements: Recognition for people or agencies without whom the work would not have been possible, but who did not actually contribute to the actual work. For example, if a scientist is doing the work using money from a funding organization, they would note that here.
- References: All scientific work builds upon the work of other scientists and this must be appropriately acknowledged. A peer-reviewed journal article frequently cites thirty or more sources in its references section. A poster limits references to the most important (~5 or so) citations. In an oral presentation, any references are displayed at the bottom of the slide that is citing that work rather than in a separate section.
- Supplemental information: Sometimes there's just too much information to squeeze into a journal article, in which case the authors put "extra" information into a section that is published separately. Items that might go in a supplemental section include more detailed methodology information, specifics of how to do difficult calculations, and raw data. (If there's a lot of raw data, the article is most likely to show it in graphical form and keep the actual raw numbers in the supplemental section.)

Alternative Layouts

Not all scientific journals publish articles with the four sections listed above. For example, some journals have a separate 'conclusion' section that separates the concluding paragraph(s) from the discussion section. Some journals combine results and discussion sections into one section named—you guessed it—"results and discussion."

Finally, some journals put the methods section last, after the discussion. This seems a bit strange until you notice that many of the journals that do this (for example, *Science*, *Nature,* and *Proceedings of the National Academy of Science*) serve a general audience that frequently include those with little scientific training. This layout allows a lay audience can read through the major part of the paper without getting bogged down in details of how it was done. Other journals that do this serve fields in which methodology is relatively standardized. (In both sorts of journals, this section is usually printed in smaller type, which further emphasizes the fact that methods are relatively unimportant to most readers.)

Poster Presentations

Poster sessions are an integral part of scientific meetings. They allow scientists to present their work in a format that's much more informal than oral presentations while also allowing for an exchange of information that's extremely tailored to the audience. The poster is a visual representation of a scientist's work but, as with oral presentations, the real wealth of information is the person standing next to it.

Because of the way poster sessions work, it is frequently possible for conference attendees to view posters without anyone present to explain the work. Posters for a given conference tend to be displayed in a large hall, arranged by topic. Presenters are assigned a time of two to three hours to stand next to their poster and answer questions about their work. However, posters can frequently be hung before the official poster session and can be left hanging after the session is over. (Depending on the venue, posters may be available for view for anywhere between one day to the length of the conference.) This makes it possible for those who need to miss a poster session to still see at least some representation of the work.

Visitors to your poster tend to be one of three types:

(1) People who find your poster at a time when you aren't standing next to it to answer questions. These types may return during the poster session to ask you questions, but it's more likely that they will only view your poster when you aren't there.

(2) People who read your abstract in the program and are specifically seeking you out to learn about your research.

(3) People who wander by during a poster session, glance at your poster, and think it's interesting enough to take a closer look.

Obviously, visitors of type #2 are the most desirable, but also the most rare. As such, a poster is best designed to cater to types #1 & #3:

- A poster should be as self-explanatory as possible, in case you're not there to give details.
- A poster should be appealing enough that someone standing 5 to 10 feet away might come for a closer look.

The one factor that makes poster presentations so difficult is that your poster is limited in size: depending on the conference, you could have a poster as big as 4' x 6' poster or as small as 3' x 4'. It is extremely hard to get months, or even years, of work compressed into that small of a space but still make the writing visible from a couple of meters away.

General tips for designing posters:

- The best tool to use for designing a poster is PowerPoint. In order to do this properly, you need to go into the 'Page Setup' menu and change the height and width of the slide to be the height and width of your poster.

- Make sure all font is large enough to read from several feet back.
  - The poster title is what's going to catch people's eyes first and therefore should be very large (60-point font at a minimum; I use 84-point type and use 60-point for contributors' names)
  - For general text, 18-point font is a minimum, and 24-point font is better.
  - You may use 16-point font for figure captions, axis titles, and references if you must—most people won't look at these without coming closer to the poster anyway—but 18-point (or larger) is better.
  - Make section headings larger than general type and bold them.

- A poster contains all "normal" sections of a scientific report. Arrange these in a logical order on your poster—scientists will expect them to be in the accepted order (Abstract, Introduction, Methods, Results, Discussion.) People in the western world naturally read top to bottom and left to right, so arrange text boxes accordingly. If you have a complicated project, it's quite acceptable to make multiple boxes for each sort of section: for example, Results from Bacteria and Results from Diatoms.

- Make sure you have good contrast between text color and background color. Using a photo as your poster background is not recommended unless you put white (or relatively light) textboxes on top of the photo in places where text or graphics will be.

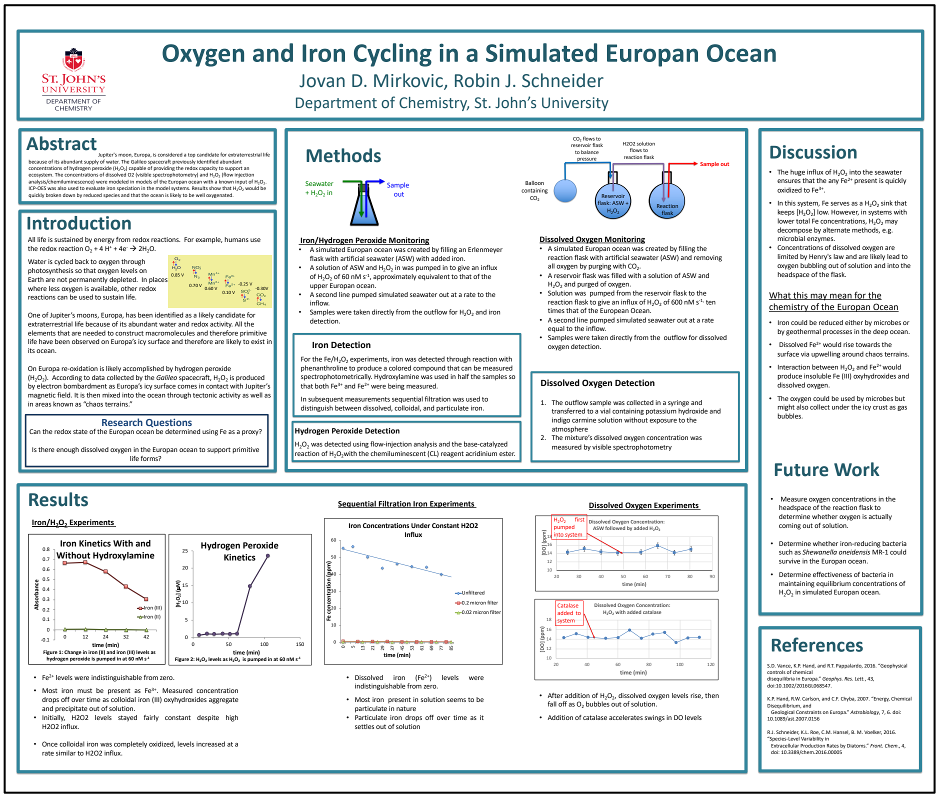
- Within these guidelines, there are many variations on what a poster might look like. See, for example, the two posters on the following page.

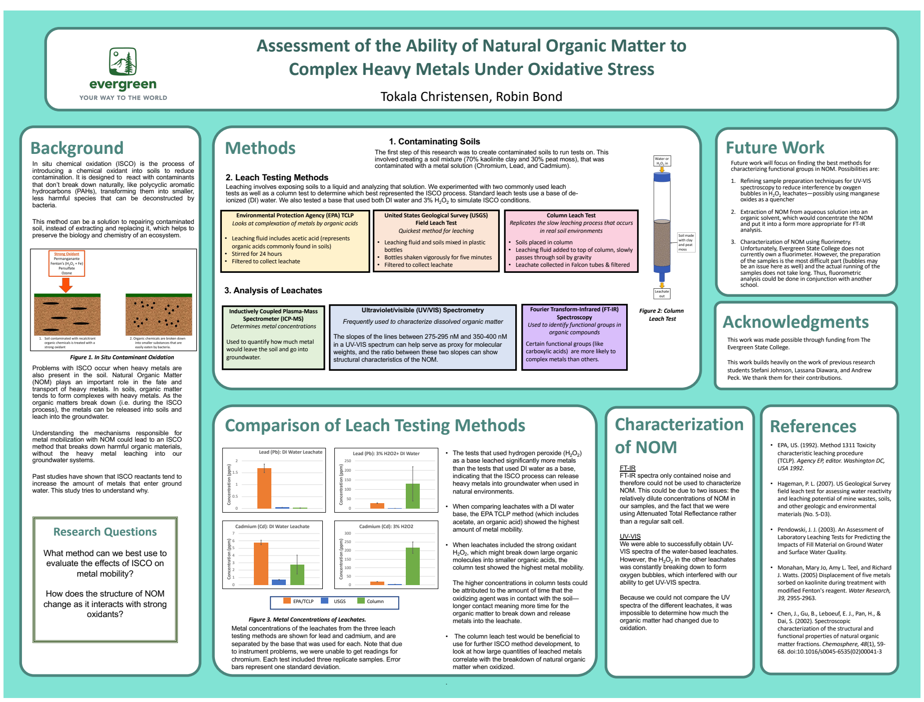
Printing your poster

- Before you actually print your poster, "preview" it by displaying the Powerpoint slide on a screen.

- In Powerpoint, create a custom paper size that's exactly the size of the poster. Select this option in the print settings, then print the slide as a PDF.

- Depending on your circumstances:
  - For a "real" poster session, submit the .pdf file to whomever is printing it. Note that printing a poster takes longer than printing a plain sheet of paper, so you may need to allow for a 24-48 hour lead time.
  - If you want to print it out full scale (for example, for a test or class) without the expense of doing a big poster, use the "poster" option in Adobe Reader. This will print it as a series of single 8.5" x 11" pages that you can tape together.


Oxygen and Iron Cycling in a Simulated European Ocean
Jovan D. Mirkovic, Robin J. Schneider
Department of Chemistry, St. John's University
St. John's University
Department of Chemistry
Abstract
Introduction
Research Questions
Methods
Iron/Hydrogen Peroxide Monitoring
Dissolved Oxygen Monitoring
Iron Detection
Dissolved Oxygen Detection
Hydrogen Peroxide Detection
Discussion
What this may mean for the chemistry of the European Ocean
Future Work
Results
Sequential Filtration Iron Experiments
Dissolved Oxygen Experiments
Iron Kinetics With and Without Hydroxylamine
Hydrogen Peroxide Kinetics
Iron Concentrations Under Constant H2O2 Influx
References


Assessment of the Ability of Natural Organic Matter to Complex Heavy Metals Under Oxidative Stress
Tokala Christensen, Robin Bond
evergreen
YOUR WAY TO THE WORLD
Background
Research Questions
What method can we best use to evaluate the effects of ISCO on metal mobility?
How does the structure of NOM change as it interacts with strong oxidants?
Methods
1. Contaminating Soils
2. Leach Testing Methods
3. Analysis of Leachates
Future Work
Acknowledgments
Comparison of Leach Testing Methods
Characterization of NOM
References

Oral Presentations

While some scientists present their research at conferences using a poster, others do so by giving an oral presentation. People may call these "Powerpoint presentations" but this is a misnomer even if you are using Powerpoint software.

During a good oral presentation, it's the presenter who is the focus of attention. While they often use Powerpoint or a similar program to help present their information, the presenter is always the one running the show.

A good oral presentation assumes that the audience can either read what's on a slide or listen to the presenter, not both. This brings us to the #1 rule of oral presentations:

The audience should be able to process each slide in 10 seconds or less.

In order for this to happen, a presenter must adhere to a few basic rules:

- Make text easy to read
- Simplify text so that the words are easy to comprehend
- Replace words/numbers with pictures (or graphs) wherever possible

Making text easy to read includes many factors, such as:

- Keeping font size large (18-pt font is a minimum, except for references, which can be 14-pt). A good test for font size is to set your computer to slideshow mode, then walk 6 feet away. If you can't read the text, it's too small.
- Maintain good color contrast before text and background. Don't use light-colored font (such as pale yellow) on a white background, or dark-colored fonts on dark backgrounds. The most challenging times to implement this rule are when using a photo for background: photos can be light in some areas and dark in others, and you may have to change font colors appropriately.
- In general, people with disabilities have an easier time reading dark fonts against a light background. Plan accordingly.

Simplifying text primarily involves reducing the number of words on a slide. Good rules of thumb are to:

- Keep bullet points to one line in length
- Have no more than 4-5 bullet points per slide

Many people protest the limits set above, stating that they can't fit all of the information on one slide. They are right, of course. But remember that most of the information that an audience gets out of the presentation, they will get from the presenter rather than the slides.

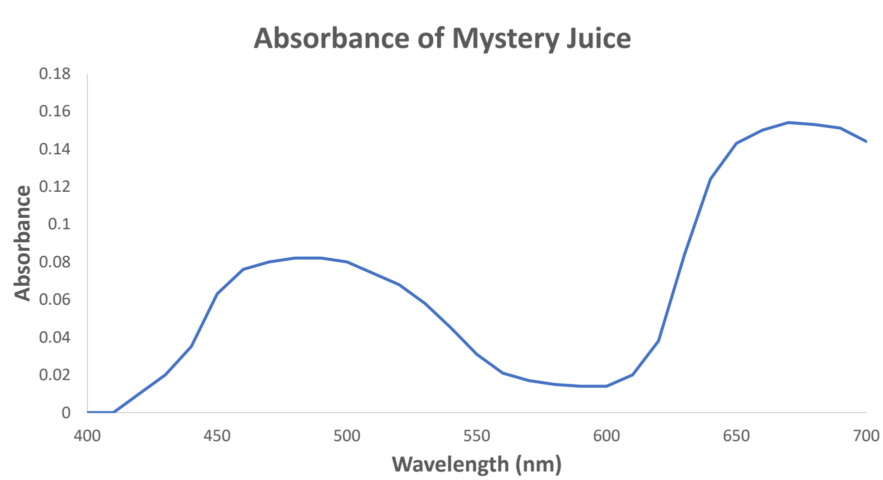
When possible, forego words (or numbers) altogether, and rely on a diagram or graph to get your point across. For example, compare the two slides on the next page. Which is easier to understand in a few seconds?

Here's some data presented in table form:

Absorbance of Mystery Juice by Wavelength

Wavelength	Absorbance	Wavelength	Absorbance	Wavelength	Absorbance
400	0.000	510	0.074	610	0.016
410	0.000	520	0.068	620	0.038
420	0.010	530	0.058	630	0.084
430	0.020	540	0.045	640	0.124
440	0.035	550	0.031	650	0.143
450	0.063	560	0.021	660	0.150
460	0.076	570	0.017	670	0.154
470	0.080	580	0.015	680	0.153
480	0.082	590	0.014	690	0.151
490	0.082	600	0.014	700	0.144
500	0.00				

Here's the same data presented in graph form:



One of the best ways to check a Powerpoint for clarity is to think carefully about each slide individually. If the audience could only take away ***one*** point from that slide, what would you want it to be? Does the slide actually help the audience focus on that one point? (Getting a neutral third party to write their take-away message from each slide is even more effective than evaluating slides yourself.)

Sections to Include in Oral Presentations

As indicated previously, you will not include an abstract in an oral presentation. You will write an abstract but it will be included in the conference program rather than your presentation. Most conferences limit these to 100-150 words, so plan appropriately.

Also, any references will be printed at the bottom of the relevant slide rather than grouped with other references at the end. An oral presentation on a scientific topic should therefore consist of four main parts, plus two slides at the end:

Introduction

- Tell why the subject is important
- Tell what's been done in the past. Give all relevant background information necessary for understanding what you did in the experiment/study.
- Try to minimize wordiness; diagrams or flowcharts are great for explaining natural processes!
- Explain what your goals/research questions were as you started the experiment. Include your hypothesis if you'd like.

Methods

- Briefly outline what you did
- Show any apparatus with diagrams rather than words when possible

Results

- If possible, show all numerical results as graphs.
  - Use scatter plots with trendlines to show trends.
  - Use bar graphs to compare measurements to other measurements
  - When possible, use error bars on either sort of graph to indicate uncertainty. (Set error bars to be equal to your standard deviation.)
  - Make sure to increase font size on legends, titles, and axis labels so that they are clearly readable by the audience.

- Show non-numerical results pictorially when possible. If pictures won't work, use bullet points of a few words each to summarize results.

Discussion

- Start by discussing the limitations of your experiment.
    - What issues limited your ability to get good results? Error analysis (see appendix B) is critical here.

    - Do your results represent very general principles, or are they limited to very specific circumstances? If the latter is true, how specific are the circumstances? (For example, if you studied great blue herons, do your results inform our understanding of all birds? All waterfowl? All herons? Just great blue herons?)

- Next, compare your results to those of previous scientific studies.
    - If you are duplicating work that has been previously done (as you might for a class presentation), it is easy enough to find previous studies.

    - If you are presenting work that no one has done before, you may have to hunt to find results that are close to yours, and even then you may have to make some assumptions. For example: I did some work on how microbes affect chemistry in the middle of the Pacific Ocean. No one had done this work before. However, someone had made similar measurements in the Gulf of Alaska, where there microbe density is about ten times as much as in my location. I therefore made the assumption that I should see 1/10 the changes that were seen in the previous study.

- Close by talking about work that you or others could do in the future to better understand the subject of your study.

Closing Slides

Most scientific presentations end with one or two closing slides.

- The first slide contains acknowledgments, thanking anyone who supported the work without actually participating in it. (For example, my acknowledgments slides tend to thank funding agencies, the school and/or department in which I/my students work, operators of any facilities that have helped us out such as research ships or outside labs, plus the people who get chemicals and fix equipment.)

- The second slide usually has a pretty picture (often taken of the lab/scientific work), thanks the audience, and prompts questions. This slide has two main purposes: it signals the presenter that it's time to ask for questions (I've actually heard famous scientists say, "Well, I guess that's the end of my presentation" which is not the note a presenter should end on) and it gives the audience something entertaining to look at while you ask questions. Not everyone uses a dedicated slide for this purpose—you can also use your acknowledgments slide to prompt for questions.

Completely optional, but highly recommended for speaking on complex topics:

If there's something that you want to include in your talk but have to leave out because of time restrictions, make a slide for it anyway, and add it to your presentation after the questions slide. Then, if someone asks a pertinent question, you can advance to that slide and show the graph or table you'd previously prepared. This is actually a really commonly used technique that I've seen many times in meetings of national/international scientific societies!

Written Lab Reports

A full lab write-up is meant to mimic the format of a scientific journal article. Formats for individual journals vary, as you will see if you read scientific literature, but in most cases the structure is relatively similar.

General Information

• Don't write in first person except in the discussion.

• Write facts. This is not an opinion paper. (More on this in the discussion section.)

• Everything should be done on computer. Taking pictures of handwritten material is not acceptable.

• Use superscript and subscripts appropriately. Water is H_2O, not H2O. Cubic centimeters are cm^3, not cm3.

• Greek letters (like delta) can be created using the Symbol font.

• Equations should be created using the equation editor ("Insert>Equation" or click the Equation button on the Insert tab) and set off from the text on their own line.

• Cite your references in the body of the text using a brief notation method (i.e. use reference numbers or name of first author); references should be written out in full at the end of the report.

Abstract

• This is a brief, condensed version of the entire report. (Most scientists will read the abstract of a journal article to decide whether they want to read the rest of an article.) See more information

• Although it appears directly below the title of a lab, the abstract is generally written last.

• For a short experiment—which, in science, is anything you spend under a month or so doing—a general guideline is to give a one sentence statement of the problem, one sentence on methods, a one sentence summary of results, and one sentence of what the results mean.

Introduction:

• Start with a sentence or two about why this work might be important.

• Discuss any background theory relating to the lab. For example, the ionic compound lab, you could discuss cations and anions (since you're doing cation and anion tests), and you might discuss solubility. In a peer-reviewed scientific journal article, this section would consist of a "literature review" in which the background theory consists of previously published research.

• The introduction should close with a brief statement (2-3 sentences or so) of what you are trying to find out with this experiment and what you expect to find.

Methods:

• Write in complete sentences and paragraph form.

• Always use past tense. (Remember, you are reporting on what WAS ALREADY DONE, not on what will be done in the future.)

• Try to be as specific as possible. For example, say "temperature was measured using a thermocouple attached to a Vernier LabQuest unit" or "a Vernier LabQuest unit with thermocouple attachment was used to measure temperature" rather than just "temperature was measured."

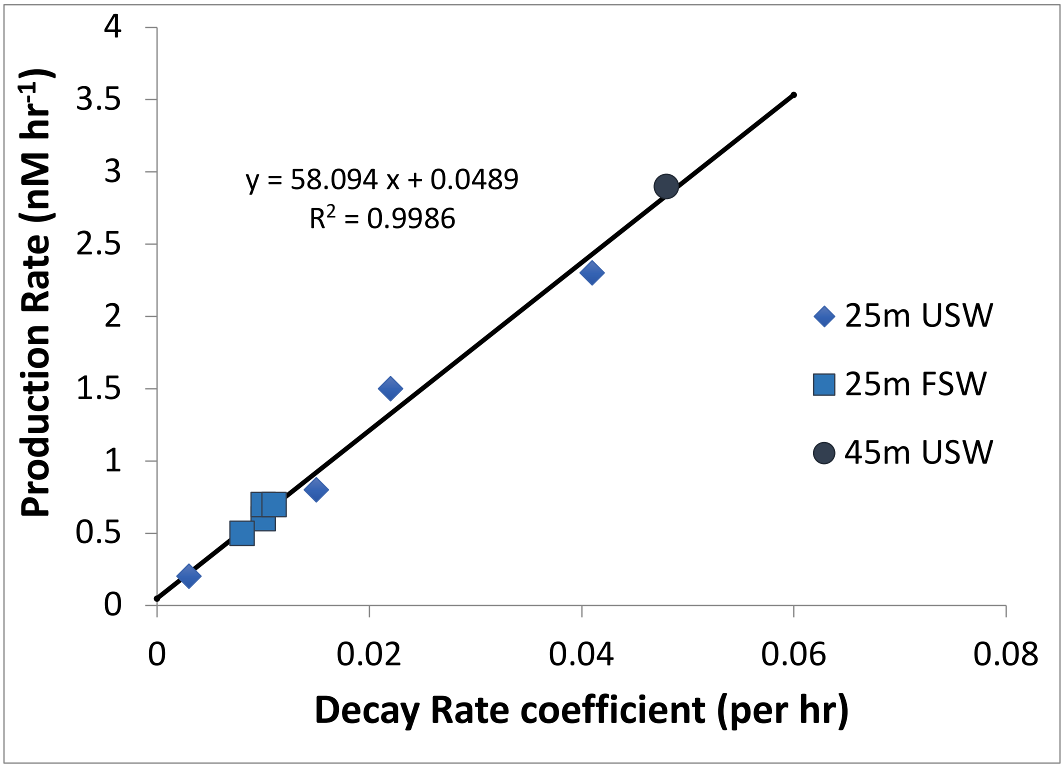
Results

• This is meant to be a summary of the data you collected. Show whatever data you can in tables and graphs; talk about general trends with text.

• Always start with any raw data you collected; calculated values come later in the results section.

• Explain how you got any calculated values. One sample calculation of each sort is good enough. (Peer-reviewed journal articles don't include sample calculations. But I've caught at least one calculation error in a published journal article so maybe they should!)

• When you have data showing a trend, display it as a "scatter plot"—see below. Use the "show trendline" feature in Excel to show any linear trends (linear equation is generally shown). If you don't think it's very linear, use the trendline options to show the R^2.



Discussion

- The point of this section is to discuss what you think the facts in the Results section are telling you. However, that does not make this an opinion section. Every conclusion here should be firmly rooted in evidence. (It doesn't matter what you "believe"…when it comes to science; belief is not sufficient. Belief is a hypothesis. You need to be past the hypothesis at this point.)

- Talk about how good your data is. This is generally done in two ways:
  (1) Do an **internal** comparison of your data by comparing all of your results. For example, a high standard deviation means that your data points from a given method are not consistent with each other. If you measure something by two different methods, are the results from those methods significantly different?
  (2) Compare your data to **external** sources, e.g. to experiments that were done previously. For a lab like the ones in an introductory class, you will be comparing to known values (or expected results based on known values) such as molecular weight. For a novel experiment, you'd be comparing to the most similar data you could find in the literature.

- How does your data support (or not) your hypothesis?

- If you think the data supports your hypothesis, how confidently can you state that? This is where a discussion of errors comes in.

- If you think the data doesn't support your hypothesis, what alternative explanations can you come up with that explain your data?

References

• Don't forget these! This is the most commonly neglected section of a report.

• Use reference citations of reliable sources (e.g., scientific journals, government databases, and the CRC Handbook of Chemistry and Physics).

• There are a number of commonly used formats for references, e.g. APA, ACS, etc. For scientific publications, the format will be picked by your journal. For class situations, your teacher will tell you. If you're working on an independent research project, reference format doesn't matter, so long as you are consistent!