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How do I present the findings from my experiment in a report?

Overview

Many believe that a scientist's most difficult job is not conducting an experiment but presenting the results in an effective and coherent way. Even when your methods and technique are sound and your notes are comprehensive, writing a report can be a challenge because organizing and communicating scientific findings requires patience and a thorough grasp of certain conventions. Having a clear understanding of the typical goals and strategies for writing an effective lab report can make the process much less troubling.

General Considerations

It is useful to note that effective scientific writing serves the same purpose that your lab report should. Good scientific writing explains:

1) The goal(s) of your experiment
2) How you performed the experiment
3) The results you obtained
4) Why these results are important

While it's unlikely that you're going to win the Nobel Prize for your work in an undergraduate laboratory course, tailoring your writing strategies in imitation of professional journals is easier than you might think, since they all follow a consistent pattern. However, your instructor has the final say in determining how your report should be structured and what should appear in each section. Please use the following explanations only to *supplement* your given writing criteria, rather than thinking of them as an indication of how *all* lab reports must be written.

In Practice

The Structure of a Report

The traditional experimental report is structured using the acronym "**IMRAD"** which stands for **I**ntroduction, **M**ethods, **R**esults and **D**iscussion. The "**A**" is sometimes used to stand for **A**bstract. For help writing abstracts, please see Sweetland's resource entitled "What is an abstract, and how do I write one?"

Introduction: "What am I doing here?"
The introduction should accomplish what any good introduction does: draw the reader into the paper. To simplify things, follow the "inverted pyramid" structure, which involves narrowing information from the most broad (providing context for your experiment's place in science) to the most specific (what exactly your experiment is about). Consider the example below.

Most broad: "Caffeine is a mild stimulant that is found in many common beverages, including coffee."

Less broad: "Common reactions to caffeine use include increased heart rate and increased respiratory rate."

Slightly more specific (moving closer to your experiment): Previous research has shown that people who consume multiple caffeinated beverages per day are also more likely to be irritable.

Most specific (your experiment): This study examines the emotional states of college students (ages 18-22) after they have consumed three cups of coffee each day.

See how that worked? Each idea became slightly more focused, ending with a brief description of your particular experiment. Here are a couple more tips to keep in mind when writing an introduction:

- **Include an overview of the topic in question, including relevant literature**
  A good example: "In 1991, Rogers and Hammerstein concluded that drinking coffee improves alertness and mental focus (citation 1991)."

- **Explain what your experiment might contribute to past findings**
  A good example: "Despite these established benefits, coffee may negatively impact mood and behavior. This study aims to investigate the emotions of college coffee drinkers during finals week."

- **Keep the introduction brief**
  There's no real advantage to writing a long introduction. Most people reading your paper already know what coffee is, and where it comes from, so what's the point of giving them a detailed history of the coffee bean?
  A good example**: "**Caffeine is a psychoactive stimulant, much like nicotine." (*Appropriate information, because it gives context to caffeine—the molecule of study)*
  A bad example: **"**Some of the more popular coffee drinks in America include cappuccinos, lattés, and espresso." (*Inappropriate for your introduction.* This information is useless for your audience, because not only is it already familiar, but it doesn't mention anything about caffeine or its effects, which is the reason that you're doing the experiment.)

- **Avoid giving away the detailed technique and data you gathered in your experiment**
  A good example: "A sample of coffee-drinking college students was observed during end-of-semester exams." (*Appropriate for an introduction)*
  A bad example: "25 college students were studied, and each given 10oz of premium dark roast coffee (containing 175mg caffeine/serving, except for Folgers, which has significantly lower caffeine content) three times a day through a plastic straw, with intervals of two hours, for three weeks." (*Too detailed for an intro. More in-depth information should appear in your "Methods" or "Results" sections.)*

Methods: "Where am I going to get all that coffee…?"

A "methods" section should include all the information necessary for someone else to recreate your experiment. Your experimental notes will be very useful for this section of the report. More or less, this section will resemble a recipe for your experiment. Don't concern yourself with writing clever, engaging prose. Just say what you did, as clearly as possible. Address the types of questions listed below:

- Where did you perform the experiment? (This one is especially important in field research— work done outside the laboratory.)
- What were your materials?
    - How much did you use? (Be precise.)
    - Did you change anything about them? (i.e. Each 5 oz of coffee was diluted with 2 oz distilled water.)
- How did you record data?
    - Did you use any special method for recording data? (i.e. After drinking coffee, students' happiness was measured using the Walter Gumdrop Rating System, on a scale of 1-10.)
- Did you use any techniques/methods that are significant for the research? (i.e. Maybe you did a double blinded experiment with X and Y as controls. Was your control a placebo? Be specific.)
- Any unusual/unique methods for collecting data? If so, why did you use them?

After you have determined the basic content for your "methods" section, consider these other tips:

- **Decide between using active or passive voice**

  There has been much debate over the use of passive voice in scientific writing. **"**Passive voice" is when the subject of a sentence is the recipient of the action.

  For example: Coffee was given to the students.

  "Active voice" is when the subject of a sentence performs the action.

  For example: I gave coffee to the students.

  The merits of using passive voice are obvious in some cases. For instance, scientific reports are about what is being studied, and not about YOU. Using too many personal pronouns can make your writing sound more like a narrative and less like a report. For that reason, many people recommend using passive voice to create a more objective, professional tone, emphasizing what was done TO your subject. However, active voice is becoming increasingly common in scientific writing, especially in social sciences, so the ultimate decision of passive vs. active voice is up to you (and whoever is grading your report).

- **Units are important**

  When using numbers, it is important to always list units, and keep them consistent throughout the section. There is a big difference between giving someone 150 milligrams of coffee and 150 grams of coffee—the first will keep you awake for a while, and the latter will put you to sleep indefinitely. So make sure you're consistent in this regard.

- **Don't needlessly explain common techniques**

  If you're working in a chemistry lab, for example, and you want to take the melting point of caffeine, there's no point saying "I used the "Melting point-ometer 3000" to take a melting point of caffeine. First I plugged it in…then I turned it on…" Your reader can extrapolate these techniques for him or herself, so a simple "Melting point was recorded" will work just fine.

- **If it isn't important to your results, don't include it**
  No one cares if you bought the coffee for your experiment on "3 dollar latte day". The price of the coffee won't affect the outcome of your experiment, so don't bore your reader with it. Simply record all the things that WILL affect your results (i.e. masses, volumes, numbers of trials, etc).

Results: The only thing worth reading?

The "results" section is the place to tell your reader what you observed. However, don't do anything more than "tell." Things like explaining and analyzing belong in your discussion section. If you find yourself using words like "because" or "which suggests" in your results section, then STOP! You're giving too much analysis.

A good example: "In this study, 50% of subjects exhibited symptoms of increased anger and annoyance in response to hearing Celine Dion music." (*Appropriate for a "results" section—it doesn't get caught up in explaining WHY they were annoyed.)*

In your "results" section, you should:

- **Display facts and figures in tables and graphs whenever possible.**
  Avoid listing results like "In trial one, there were 5 students out of 10 who showed irritable behavior in response to caffeine. In trial two…" Instead, make a graph or table. Just be sure to label it so you can refer to it in your writing (i.e. "As Table 1 shows, the number of swear words spoken by students increased in proportion to the amount of coffee consumed.") Likewise, be sure to label every axis/heading on a chart or graph (a good visual representation can be understood on its own without any textual explanation). The following example clearly shows what happened during each trial of an experiment, making the trends visually apparent, and thus saving the experimenter from having to explain each trial with words.

Table 1

Amount of coffee consumed (mg)	Response to being poked with a pencil (number of expletives uttered)
50	0
75	1
100	3
125	4
150	7 ½

- **Identify only the most significant trends.**
  Don't try to include every single bit of data in this section, because much of it won't be relevant to your hypothesis. Just pick out the biggest trends, or what is most significant to your goals.

Discussion: "What does it all mean?"

The "discussion" section is intended to explain to your reader what your data can be interpreted to mean. As with all science, the goal for your report is simply to provide *evidence* that something might be true or untrue—not to prove it unequivocally. The following questions should be addressed in your "discussion" section:

- **Is your hypothesis supported?**
  If you didn't have a specific hypothesis, then were the results consistent with what previous studies have suggested?
  A good example: " Consistent with caffeine's observed effects on heart rate, students' tendency to react strongly to the popping of a balloon strongly suggests that caffeine's ability to heighten alertness may also increase nervousness."

- **Was there any data that surprised you?**
  Outliers are seldom significant, and mentioning them is largely useless. However, if you see another cluster of points on a graph that establish their own trend, this is worth mentioning.

- **Are the results useful?**
  If you have no significant findings, then just say that. Don't try to make wild claims about the meanings of your work if there is no statistical/observational basis for these claims—doing so is dishonest and unhelpful to other scientists reading your work. Similarly, try to avoid using the word "proof" or "proves." Your work is merely suggesting evidence for new ideas. Just because things worked out one way in your trials, that doesn't mean these results will always be repeatable or true.

- **What are the implications of your work?**
  Here are some examples of the types of questions that can begin to show how your study can be significant outside of this one particular experiment: Why should anyone care about what you're saying? How might these findings affect coffee drinkers? Do your findings suggest that drinking coffee is more harmful than previously thought? Less harmful? How might these findings affect other fields of science? What about the effects of caffeine on people with emotional disorders? Do your findings suggest that they should or should not drink coffee?

- **Any shortcomings of your work?**
  Were there any flaws in your experimental design? How should future studies in this field accommodate for these complications. Does your research raise any new questions? What other areas of science should be explored as a result of your work?

Resources:

Hogg, Alan. "Tutoring Scientific Writing." Sweetland Center for Writing. University of Michigan, Ann Arbor. 3/15/2011. Lecture.

Swan, Judith A, and George D. Gopen. "The Science of Scientific Writing." *American Scientist*. 78. (1990): 550-558. Print.

"Scientific Reports." *The Writing Center*. University of North Carolina, n.d. Web. 5 May 2011. http://www.unc.edu/depts/wcweb/handouts/lab_report_complete.html