

# How to Write Your Lab Report for Chem 201

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Submitted for course Chem 201

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The first page is the title page--complete with a title, your name, partner's name(s), etc. The title page gets no page number. Subsequent pages are numbered.

## Manuscript format:

- *11-point Arial or 12-point Times Roman fonts.*
- *Margins are 1" all around.*
- *Text is double spaced.*
- *Paragraphs (except for ABSTRACT if it is a single paragraph) have a "tab" indent.*
- *Be sure to have a header inserted (see next page for header format).*
- *Use a formal writing style, and say what you mean succinctly. Don't be flowery.*
- *Don't use colloquial language. Don't use slang. Avoid contractions (sorry I broke that rule). Writing that you got a "really big response" says little. How big was it?*

## **ABSTRACT**

The ABSTRACT functions as a mini-paper. It succinctly summarizes what was said in the report.

The ABSTRACT should have several brief parts (1-3 sentences) in the following order: (a) statement of purpose, (b) experimental approach, (c) experimental elements that are key to the experiment, (d) major results, (e) comment on what the results mean or major problems arising that complicate interpretation, and (f) conclusion. Give the key results and data that are necessary to support your conclusions. Give real values—do not say “we measured some stuff” and got this conclusion.

The ABSTRACT usually appears in most journals as a single paragraph, although separate paragraphs can be used for each key element stated above. Most journals have a limit of ~250 words on the ABSTRACT, but you can have more.

You do not need to start each section on a new page.

Who should you address your writing to? Who is the audience? For this class and these reports, address our writing to your peers: junior/senior chemistry students.

## **INTRODUCTION**

The INTRODUCTION does exactly what you expect: it (a) introduces the problem to be addressed and (b) tells why the work being done is important. The INTRODUCTION then goes on to tell (c) something about the experimental approach used in the experiment and why. The minimum length of the INTRODUCTION would therefore be 3 paragraphs. Think of the introduction to be an overture to the work.

When you cite the work of others, cite it using parentheses as shown here. For example, I have published work looking at how leucine is metabolized in the body (1) and how amino acids

are absorbed by the gut and liver (2-4). I have published some chapters in books (5). My laboratory has also developed a new method for measuring homocysteine (6).

In a real journal article, the introduction generally runs 2-3 typed pages. Your INTRODUCTION may be as short as a page.

## EXPERIMENTAL

Each section in the experimental section has a sub-heading that is set off in bold. The sub-sections are shown below. Not all sub-sections may be required. NOTE: If you develop an equation or relationship etc from the data that you have collected, then that material goes in the RESULTS and DISCUSSION sections, not in the EXPERIMENTAL section. The EXPERIMENTAL section is only for what you know when you started the study.

Other big points:

- **DON'T** give results in the experimental section. Save results for the next section.
- **Write in the PAST tense** (includes almost all of the report). You are reporting about what you *DID*, not what you are *DOING* (present tense), and certainly *not what you are planning to do* (future tense).

**Theory.** Place here the background material required to explain your results. The theory may include material leading up to what you explain in the **data analysis** sub-section that follows. For example, if you are doing IR, then the theory as to how the rotational and vibrational components arise and are measured go here. This section would include appropriate citations to the literature. This section will demonstrate that you understand what you are doing in this experiment, but it is not necessary to regurgitate the literature verbatim—just state the critical elements required to understand the experiment.

**Materials.** State the chemicals, reagents and solutions that you used. Say what the materials are and where you got them. If they were provided to you, state who gave them to you and what you know about their history (when prepared etc.). If the materials came from a manufacturer, give the manufacturer's name (and location in parentheses). For example:

Reagent-grade glucose was obtained from Sigma Chemical Comp. (St. Louis), and *N*-methyl-*N*-(*t*-butyldimethylsilyl)-trifluoroacetamide (MTBSTFA) was obtained from Pierce Chemical company (Rockford, IL).

**Instrumentation.** If specific piece(s) of instrumentation are central to the experiment and were used in specific modes, so state. Give the name, model, manufacturer and key features of the instrument. State its specifications as it relates to your experiment. For example, how high a resolution do you need to make your measurements and what resolution does the instrument routinely provide?

**Procedures.** Here is where you outline your experiment(s). Give an overview paragraph of the experiment(s) first; then give individual paragraphs concerning each experiment or sub-part. State clearly and succinctly what you did.

At this point an argument develops among scientists as to how the procedures should be described. The predominant approach to defining procedures has been to use “passive voice”. A *simple example is*: Samples were collected in 10-ml tubes, and the solvent evaporated under a stream of dry N<sub>2</sub> gas. When the tubes were dry, the derivatizing reagent was added. The tubes were capped and heated for 30 min at 100° C in an aluminum heating block.

The alternative form is “active voice”, which is generally the preferred form of writing – except in science. Why? because active voice requires the use of the “1<sup>st</sup> person”. However, “active voice” writing is becoming more accepted. A simple example is: We (or I) collected the samples in 10-ml tubes and then removed the solvent by evaporation under a stream of dry N<sub>2</sub> gas. When the tubes were dry, we added the derivatizing reagent, capped the tubes, and heated them for 30 min at 100° C in an aluminum heating block.

It's up to you to choose which voice you use. However, be consistent throughout. Likewise, be careful about tense. Generally, procedures are written in the past tense because that's when they were done. However, the data analysis section is often written in present tense. The main point is that you must use a consistent tense throughout a section and, especially, a paragraph. Also, do not start a lot of sentences with adverbs or conjunctions.

*This previous paragraph is such an example. Note the use of "however," "generally," "likewise", "also" and (I left out) "therefore." Use these words occasionally for emphasis, but do not fall into the easy trap of starting a whole series of sentences with them.*

**Data Analysis.** You succinctly and logically state the calculations you perform in this section. This section should describe how all results were calculated from data that you collected in your experiments. The RESULTS and DISCUSSION sections should not need to state or restate your calculations—they should be defined here. You give the key equations you used to calculate your data. You define all variables in the equation (generally after stating the equation), and you give units of measure for all variables. Simple equations can be written using normal word-processing. Really simple equations can be worked into the text. An example is: Blood glucose concentration ( $[G]$ , mM) was the product of the measured glucose per sample ( $n_G$ , nmol) and sampled aliquot ( $V$ ,  $\mu$ l):  $[G] = n_G V$ . For this reason, variables are often stated in *italics* to make identification in text easier.

When an equation is longer, it is set off in its own paragraph. All equations that are set off on their own line should have an equation number in parentheses at the right. An example is:

Homocysteine was determined from the ion intensity ratio of unlabeled homocysteine to [ $^2\text{H}_4$ ]homocysteine ( $R_{0/4}$ ):

$$n_0 = n_4 \cdot [R_{0/4} - R_{0/4(4)}] / k_{0/4}, \quad (3)$$

where  $n_0$  is the amount of homocysteine (nmol),  $n_4$  is the amount of  $[^2\text{H}_4]$ homocysteine added to the sample (2 x the amount of  $[^2\text{H}_8]$ homocysteine),  $R_{0/4}$  is the measured  $A_{411}/A_{415}$  ion intensity ratio, and  $R_{0/4(4)}$  is the  $A_{411}/A_{415}$  ion intensity ratio when pure  $[^2\text{H}_4]$ homocysteine is injected.

*Statistics.* The final component of data analysis is “statistics”. How did you prove that a given result was significant? Here is where you state what kind of statistical tests you applied to the data: unpaired or paired t-tests, one-tail or two-tail, analysis of variance, linear regression analysis, etc.

When you express results in the paper and give mean values of several determinations, you want also to give the corresponding uncertainty in the form of the standard error of the mean (or standard deviation, depending upon the context). The same is true for plotting data points that are mean values. You need to provide standard error bars. Here is where you state what conventions you will use for expression of your data in the manuscript.

The length of the EXPERIMENTAL section will probably be ~2-4 pages (assuming no background theory is required).

**BIG POINT: “data” is PLURAL!! “Datum” is singular. Don’t ever say: “the data shows...” It’s “the data show.”**

## RESULTS

**Are you thinking:** "Whoah! I have read several pages of instructions, and I am just now getting to the RESULTS. It's going to take forever to write this report. How many of these things do I have to write this semester?" **Writing these reports gets easier with each one that you write—kind of like doing sit ups every day. The big IF to make report writing go quickly is if you are prepared when you start writing. Do you have your thoughts and your data organized? The key to organization starts before the lab begins. If you don't understand the theory of the experiment or what you were doing when you were doing it, you are probably in trouble now.**

**Therefore, the key word to the wise is COME TO THE LAB PREPARED IN ADVANCE OF DOING THE LAB. Don't assume that you can learn what you need after the lab is done.**

The RESULTS section is exactly what it says: *your* experimental results. The key to the RESULTS section is an organized layout that builds logically from the simple and basic to the complex. Results that depend on earlier results come later. Make this section a logical development of your data. Do not give data that you did not obtain. If you want to discuss data that come from the literature or someone else's work, save it for the DISCUSSION. Some interpretation of the results may be given in this section (e.g. statistical analysis of significance), but discussion of the results and their importance comes in the next section.

The RESULTS section is where almost all the tables and figures are cited. *Use Arabic numbering for your tables and figures. Put tables and figures on separate pages after the written text (see below). Capitalize references to specific tables and figures, such as "Table 2" or "Figure 1."* Do not restate material found in the tables and figures verbatim in the RESULTS (especially table data). Summarize the tables and figures in the RESULTS section.

**Back up and re-read the previous paragraph, paying particular attention to the parts in italics.**

**Back up and re-read the previous paragraph another time. Every year students ignore these instructions, but not you, *non vero?***

Once you have prepared tables and figures of your data, the RESULTS section will write itself and may only be 1-2 pages. The simplest approach is to think of the RESULTS section being

one paragraph describing each figure and/or table (if the data in the table matches or tabulates what is in the figure, both can be in the same paragraph). The important point is DO NOT jam description of several figures into a single paragraph. Paragraphs are complete thoughts, and so should be individual figures. You need to introduce the figure, explain the figure, and summarize what the figure tells you ← that is what a paragraph represents.

Tell a story with the RESULTS section. Yes, you can repeat (briefly) some of the introductory material to start the story off. Tell the reader what you first did and why. For example, you may have taken several spectra at different resolutions and conditions with the spectrometer to see the effect of spectrometer settings had on the resulting spectra. Then you may have used the optimal settings obtained in the first part to take experimental data. If so, start out by telling the reader that “before you could investigate the spectroscopic properties of the compound dimugleoglugtane, you first needed to optimize the conditions of the spectrometer. To do that you first measured trimethylsimplene as the model compound to test various spectrometer parameters.” Then you can present your data for this part: “Fig. 1 shows the spectrum of trimethylsimplene obtained where \_\_ resolution was used. Note that the individual peaks overlap. However, when resolution was increased to \_\_, the individual peaks became resolved (Fig. 2).” ...and so on to tell the story of your RESULTS of your experiments in a logical fashion.

## **DISCUSSION**

This section is where you discuss your results. That is, you say what is important about them--good and bad. You give their strengths and weaknesses. You put your results in context with information already in the literature. If you are presenting new and original work, you discuss how your work is making a new and important contribution beyond what we already know.

Often times, the first paragraph of the discussion is a restatement of the problem and why you are doing what you are doing. That paragraph makes it easier to slide into giving the strength and weaknesses of your findings and comparing your results with the literature.

Although it is not mandatory, most people have a final paragraph in their discussion that serves as a conclusions paragraph. The conclusions paragraph serves to summarize the important findings of the work.

The length of the DISCUSSION section is dependent upon what you have to say. I would guess that 2-5 pages should suffice.

## **ACKNOWLEDGEMENTS**

Anyone important that needs to be acknowledged who contributed to this work? Grant support that helped fund the work? This section covers these acknowledgements. You will probably not need this section.

## **LITERATURE CITED**

References will be cited in the text using parentheses and then listed here numerically by citation order. You can use either standard ACS format or J. Biol. Chem. format for the citations. The references you see below are J. Biol. Chem. format.

The purpose of citations is to give credit where credit is due. **DO NOT** quote anything from the literature without putting quotes around what you are "quoting." Generally writers do more than paraphrase work from the literature,

and most references are as shown in the INTRODUCTION: acknowledgements for work, thoughts, and contributions by others to our knowledge base.

1. Matthews, D. E., Bier, D. M., Rennie, M. J., Edwards, R. H. T., Halliday, D., Millward, D. J., and Clugston, G. A. (1981) *Science* **214**, 1129-1131
2. Matthews, D. E., Marano, M. A., and Campbell, R. G. (1993) *Am. J. Physiol. Endocrinol. Metab.* **264**, E109-E118
3. Matthews, D. E., Marano, M. A., and Campbell, R. G. (1993) *Am. J. Physiol. Endocrinol. Metab.* **264**, E848-E854
4. Haisch, M., Fukagawa, N. K., and Matthews, D. E. (2000) *Am. J. Physiol. Endocrinol. Metab.* **278**, E593-E602
5. Matthews, D. E. (1999) Proteins and amino acids. In Shils, M. E., Olson, J. A., Shike, M., and Ross, A. C., editors. *Modern Nutrition in Health and Disease*, Williams and Wilkins, Baltimore, 11-48
6. MacCoss, M. J., Fukagawa, N. K., and Matthews, D. E. (1999) *Anal.Chem.* **72**, 4527-4533

## **APPENDICES**

**#1.** Give a title

**#2.** Give a title

If you have material that is relevant to your report in the form of complex spectra, long lists of data, etc that do not readily go into a making a simple table or figure, then these materials may be attached as appendices to the end of the report. However, you need to provide a page here that indicates their presence, listing each piece of material with a sequential number and title. These numbers and titles should also be on each appended set of material.

**Table 1.** Give a title for each table.

Sample	What was measured type 1 (give units)		Another type of measurement (units)
	1 <sup>st</sup> measure	2 <sup>nd</sup> measure	
A	1.15	4.00	12.0
B	2.23	4.44	10.0
C	1.80	4.30	9.8
Mean	1.73	4.25	10.6
S.D.	±0.54	±0.22	±1.22

In the footnote to the table you can provide extra details about what is what or how this was calculated etc, but be brief and succinct.

Tables should not be overly complex or contain unrelated material. Each table should carry its own message.

You can cut and paste Excel spreadsheets into here if you like-just be sure the table is readable. Don't provide huge tables. Huge tables should be given as appendix material.

Be sure to report only the appropriate number of significant digits. In the example above, individual data points may be reported from the instrument with more digits than shown, but the reproducibility (defined by the S.D.) does not demonstrate more than 2 decimal places of significance for any set of data in the table. In fact, the 3rd column could almost be truncated another digit.

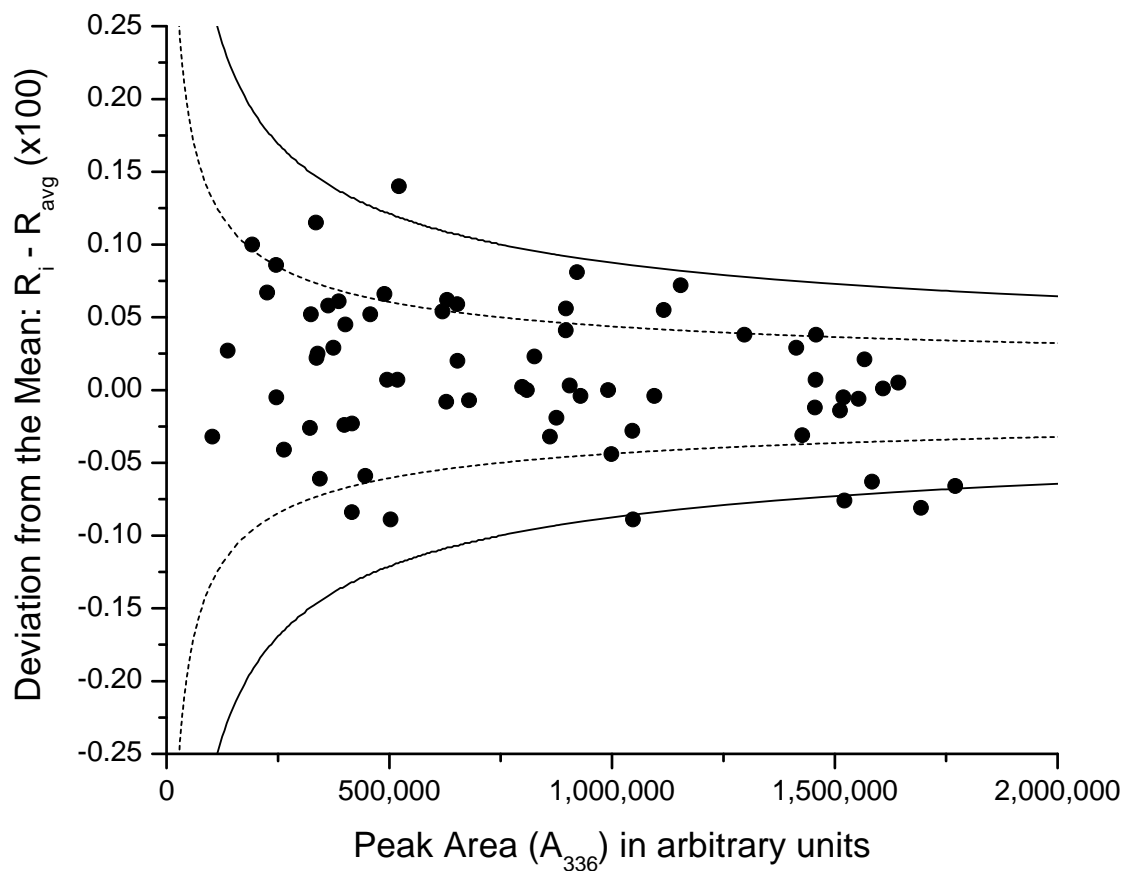
**Figure 1.** Give a title sentence for the figure. Then give any supporting sentences you need to explain the figure and tell what is what on the figure.

Normally, figure legends are given together as text, separate from the figures. For this course, I ask you to put the legend at the top of each figure. This section can be typed single space to save room.

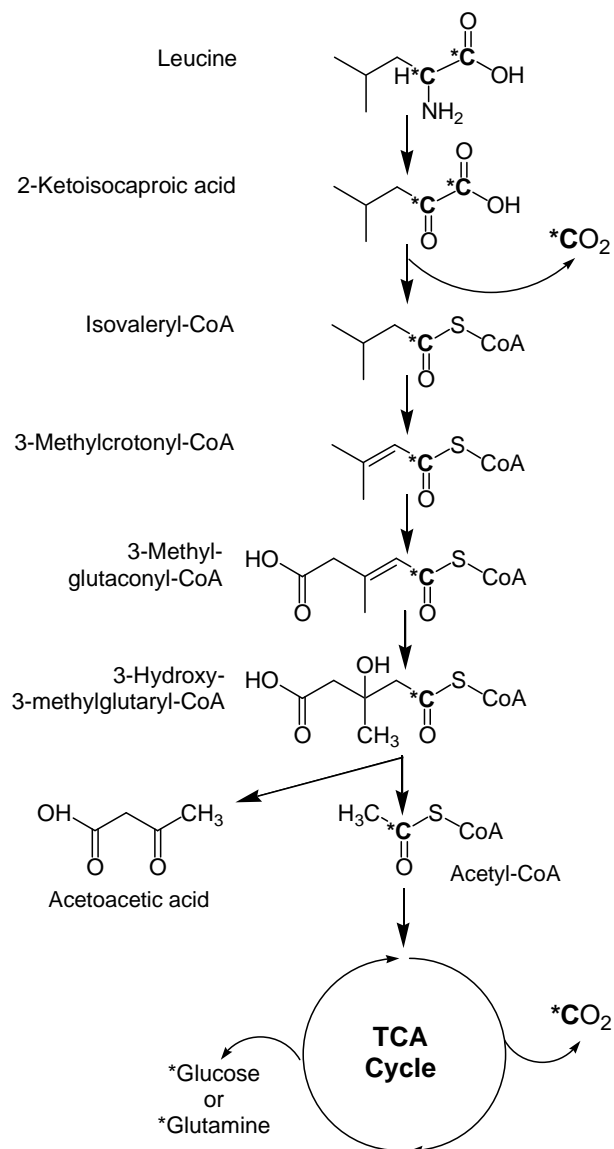
The easiest thing to do is cut/paste the figure directly from Excel or whatever software you are using directly into the word processing file. Doing so gives you a file that stands alone and can be transmitted electronically. I include such a file as a figure here.

Be sure to mark your figure axes clearly. Be sure to use large enough type to be readable. Use only the appropriate number of significant figures in your axes. Don't have values of "0.000, 2.000, 4.000, 8.000" when "0, 2, 4, 8" are more readable and simpler. The exception is if you cut/paste a graph from an instrument's output of which you cannot control the format.

If you "scan" a figure, be sure that it is saved compactly as a JPEG, TIF, or GIF format and that it is clearly readable.



**Figure 2.** Insertion of a Chem Draw figure. The next sentence or two would explain the figure.



### Other notes about figures: (please read and follow instructions)

Microsoft Excel is a very easy way to prepare high quality graphs, but Excel does several bad things as its default that you need to correct immediately:

1. When you prepare a graph, you almost always want to choose the “XY Scatter” plot. DO NOT choose “Line”: you get even spacing of the x-symbols, regardless of their value.
2. **VERY IMPORTANT:** Excel puts a gray background on the plot so that light color symbols (like yellow) will show up. However, you should never be using yellow or other light symbols in a manuscript. *What you need to do for every plot you makes:*
  - a. Right mouse button in the middle of the chart to get the “Format Plot Area” option to come up. Select & then click the “none” radio button under AREA on the top right side of the box – that turns off the gray
  - b. Also get rid of any grid lines by right-mouse button in the middle of the chart to get the “Chart Options” option to come up, and select the grid lines tab to turn them off. You can add titles to your axes through this same approach
3. Format your x & y axes by putting the cursor over either axis and hitting the right mouse button to call up the edit the axis dialog:
  - a. Set the font to be appropriate (i.e. bigger).
  - b. Set the scale.
4. You normally handing in black & white lab reports. If you want to use colors, use dark colors for your curves and data points and edit them to be of appropriate size and line thickness. You can do this by putting the cursor over a curve or data point and hitting the right mouse button. Select “Format Data Series”. Use different symbols and/or open & filled symbols to distinguish different sets of points.

Every figure MUST have a **figure legend** that includes the figure number, a title sentence and one or more sentences that explain the figure, its symbols, etc. You may put the figure legend in one of three places:

1. On a FIGURE LEGEND page(s) where all the figure legends are placed
2. On individual figure pages with the figure – this approach can crowd the figure on the page
3. On a separate page that precedes the actual figure.

## **SOME GRAMMAR DO'S & DON'TS:**

**WRITE IN PARAGRAPH style.** A paragraph should develop a complete thought. If you have multiple thoughts, then they each go in their own paragraphs.

What needs to be in a paragraph:

1. *An introductory sentence.* You need to lead into or introduce the thought you are trying to develop in the paragraph.
2. *The paragraph body of one or more sentences.* Here you develop logically your thought, idea or statement.
3. *A concluding sentence.* You need to now wrap up and conclude your thought. Don't just end a paragraph with the "and then they were all run over by a truck" approach. Finish off your thought with a summary.

By the above definition every paragraph needs 3 sentences minimum (you might get by with two, but do not write a one sentence paragraph).

1. REMEMBER: "**data**" is plural and "**datum**" is singular.
2. "**Because**" is just that: cause & effect. "**Since**" defines a relationship of time. They define different things. Example:  
    "Because she left me for another guy, I have taken to drink."  
    "Since she left me for another guy, I have taken to drink."  
Your use of "because" and "since" should also be appropriate
3. Only proper nouns are capitalized. You don't put **Methane** in a **Beaker**. You put methane in a beaker (but it won't stay there for long). However, you write in English, not German (these words are capitalized as proper nouns).
4. It's easy to keep "**effect**" and "**affect**" straight if you always use "effect" as a noun and "affect" as a verb. Example: "The effect I saw affected me personally."
5. Always put a **leading zero** before a decimal fraction. DO NOT write ".5"; always write "0.5".
6. Put a space between a number and its units. DO NOT write "0.5ppm"; always write "0.5 ppm".
7. Do not start a sentence with numbers. E.g. "2.5 ml were put into a tube." ← not good. You have two choices:
  - Write out the starting number: "Two and one half milliliters were put into a tube" ← this option is pretty awkward in this case.
  - Add some words at the beginning. Examples:
    - "First, 2.5 ml were put into a tube." or
    - "About 2.5 ml were put into a tube."

8. “This” and “that” are often used as demonstratives that can be used as adjectives or as pronouns (see Wikipedia if you are not sure what “this” is). When you write, you will almost always be using “this” and “that” in an adjectival sense, not a pronoun. As an adjective, “this” and “that” need noun modifiers.
- Examples as demonstrative adjectives:
    - “This measurement is correct.”
  - Examples as demonstrative pronouns:
    - “This is correct.” ← what exactly is correct?

The problem with the use of “this” or “that” as pronouns is that you cannot really understand what is being described. “This” what? *When using “this” and “that” as demonstratives, please use them as adjectives and provide a noun modifier.*

9. On to relative pronouns. A relative pronoun is a pronoun that marks a relative clause within a larger sentence. The usual problem in science writing is properly using “that” and “which”. However, it’s easy to keep the relative pronouns “**that**” and “**which**” straight if **you always use “that” when the clause you are writing is necessary** to be there and “**which**” **when the clause is not necessary** (the clause could be parenthetical).
- A comma is always put in front of “which”, but never in front of “that”.

Examples:

“The compound that produced an absorption band at 300 nm is isobutylbenzene.” ← the 300 nm peak is important in the identification

“The compound, which produced an absorption band at 300 nm, is isobutylbenzene.” ← the 300 nm peak is not necessarily the identifying feature, but the detail has been added for completeness

**10. Do not split infinitives:**

- Correct: “To obtain the spectrum rapidly, we scanned fast.”
- Incorrect (sucks): “To rapidly obtain the spectrum, we scanned fast.”

11. If you need a “micro”, you can get it cheap by holding down the Alt key and typing on the number pad to the right (be sure Num Lk is down): “230”, which generates a “μ”
12. If you need a “plus-minus sign”, you can get it cheap by holding down the Alt key and typing on the number pad to the right (be sure Num Lk is down): “241”, which generates a “±”. Another way is to type a “+” then underline it: “±”. **DO NOT** type “+/-”.
13. These symbols and others can also be called up from MS Word through the “Insert” “Symbols” pull down.
14. Did I mention, **write in PAST tense**? Certainly you should not write in FUTURE tense.

**Editing marks that you *may* find on your graded lab report:**

- # insert a space or insert a line
- ¶ Paragraph symbol; used to indicate where you should start a new paragraph
- awk awkward

- gack self-explanatory; something worse than awkward
- lc lower case
- uc uppercase
- w/ with

**Other *How to Write Good* links:**

- [www.plainlanguage.gov](http://www.plainlanguage.gov) – a web site devoted to assist people in effectively communicating with their audience.
  - This site has pages specifically on real examples of bad writing (especially by government employees).
  - It also has pages of *how to* guidelines and manuals.
  - My favorites:
    - Plain English at a glance:  
<http://www.plainlanguage.gov/howto/quickreference/glance.cfm>
    - Tips on how to write good:  
<http://www.plainlanguage.gov/examples/humor/writgood.cfm>
- [http://workableweb.com/pages/tips\\_how\\_to\\_write\\_good.htm](http://workableweb.com/pages/tips_how_to_write_good.htm) – a reproduction of the original National Lampoon article by Michael O'Donoghue on “How to Write Good”.