

Writing A Scientific Paper

Writing is easy. All you do is stare at a blank sheet of paper until drops of blood form on your forehead.
Gene Fowler

Brilliance has an obligation not only to create but also to communicate.
J.R. Platt

The trouble with most of us is that we would rather be ruined by praise than saved by criticism.
Norman Vincent Peale

INTRODUCTION: A major goal of this course is the development of effective technical writing skills. To help you become an accomplished writer, you will prepare several research papers based upon the studies completed in lab. Note that research papers are not typical "lab reports." The latter tend to be informal internal reports, or in a teaching lab, answers to a set of questions.

BASIC INFORMATION/INSTRUCTIONS ABOUT YOUR PAPER:

Length of Paper – There is no minimum length nor is there a maximum length for the paper. This is likely to be about 8 to 12 pages with figures. Longer papers will be more the rule than the exception. We do not grade based on length but rather completeness and the manner in which you communicate your work from the semester.

The following guidelines may depend on your research advisor. She or he will determine the ultimate appearance and formatting of your research manuscript.

Appearance:

- Manuscripts must be typed with **1.5 line spacing** throughout with at least one half -inch margins on all sides.
- The text must be typed in a font size of at **ten points** using **Arial Font**.
- Following the title authors and addresses, the remaining portion of the manuscript must be in **two columns** with the **figures imbedded** into the text. This will take time, but managing your format in this manner is an important soft skill.
- Include page numbers on all pages with the running title and last name of the first author in the header of each page after the first page. To do this, in Microsoft Word, click on the "Insert" menu and chose the page numbers option. In that window you will have the option to show numbers on the first page. Do not show numbers on the first page and then when you add a header in the second page, all subsequent pages will have the running title.

Arrangement - The manuscript is to be arranged in the following order: (a) title, author(s), and complete name(s) of institution(s); (b) running title; (c) summary; (d) introduction; (e) experimental procedures; (f) results; (g) discussion; (h) references; (i) footnotes; (j) figure legends; (k) tables; and (l) figures. Number all pages with the title page as page 1. Begin each section on a new page. Indicate by marginal notes the suggested location in the text of each figure and table.

Level of Detail in Your Writing – This should NOT read like a recipe, a lab book protocol, OR the protocols from the web. The best way to understand how these papers should look is to read several published journal articles.

BAD - *A column of DEAE was run to purify MDH.* While correct, this way off writing is too terse and will NOT receive C grade. Instead details, background and supporting evidence are critical..

OK – *10 ml of lysates was applied to a DEAE column and the MDH was eluted with a pH change...* Much better than the last attempt, but this does not give enough information to help the reader know what and why you did the experiment, not does it communicate how you did it.

Better but not complete – *After diluting 10 ml of lysate with 20 ml of 10 mM Tris-Cl, pH 8.0, 0.1 mM EDTA and 0.5 mM DTT (DEAE Wash Buffer), the sample was loaded onto a 15 ml DEAE-Sephacel column (1.0-5 cm) equilibrated with five column volumes (CV) of DEAE Wash Buffer at a flow rate of 1.0 ml/min. The column was then washed with two CV of DEAE Wash Buffer before eluting the MGH with a 10 CV gradient of 0-250 mM NaCl in DEAE Wash Buffer. Throughout the gradient, 2.5 ml fractions were collected...* See the a specific journal or paper for more examples and style.

Tips –

In general, past tense is used as an objective description of the results. Even in the methods section do not write instructions rather than a report of what was done. In other words, do not write Then add 1.0 ml of Bradford reagent. Rather 1 ml of Bradford reagent was added to each sample.

Avoid the use of first person I did not see an increase ... instead use the absorbance increased over time.

Avoid the use of pronouns. Overuse of words such as those, this, them, and so on, simply muddy up your writing style. Remember your assignment is a formal paper and writing needs to be clear.

Style – READ the assigned pages in at the bench and writing about biology AND read the JBC paper. You can NOT read the assignments and the JBC paper enough times! Look for style in each section. DON'T try to write "fancy". Write in a similar manner that you speak, just more formally. Again – look at the JBC paper for your guidance.

Oops – If something didn't work (such as a gel) be aware of it, but don't belabor the point. This is not an opinion piece. Therefore your paper should not include your feelings about if you liked or didn't like something. Critiquing that you would do something again to be certain doesn't belong in this kind of a paper either.

Proofing – read the paper out loud a paragraph at a time. If what you are hearing doesn't sound like what you meant, then you need to edit each line. This is an easy but effective method in checking your structure and readability.

Abbreviations can be used for words used many times after first spelling it out then followed by the abbreviation. "protein kinase C (PKC)" Exceptions to the rule are widely used abbreviations such as NaCl, ATP, NADH and so on. A rule of thumb is if it is a common chemical then you don't need to spell it out if you don't know it off of the top of your head then spell it out and introduce the abbreviation

How to think of and organize your paper/manuscript

Start with your initial hypothesis then layout the figures.

Next consider your hypothesis as a story.

- Use the figures and the hypothesis to determine one, two or three summary statements; questions your studies will answer. The hypothesis and summary statements should organize each section of the manuscript. These are the take home message or question your paper answers.
- Use short sentences which use cause and effect words (necessary, influence, predict, causes) to generate your summary sentences.
- Get your story to an elevator speech and stick to the point throughout the manuscript.

SECTIONS OF THE PAPER

- Stay focused on the research topic of the paper
- Use paragraphs to separate each important point (except for the abstract)
- Present your points in logical order
- Use present tense to report well accepted facts - for example, 'the grass is green'
- Use past tense to describe specific results - for example, 'When weed killer was applied, the grass was brown'
- Avoid informal wording, addressing the reader directly, and jargon or slang terms
- Avoid use of superfluous pictures - include only those figures necessary to presenting result
- Determine appropriate journal, read instructions to authors and get two or three examples from same journal of similar papers to use as templates.
- Tell a good story – be complete but concise.
- Follow a cadence or algorithm for each section. Keep the flow going, wordsmith later.

Figures: Work on details for publishable quality figures– too specific for this presentation.

- Include rough drafts of legends. Use summary statements for headers of each figure legend to help organize the thoughts.
- Arrange the figures in order to tell the best story not always chronologically.
- Creating and arranging the figures first helps to determine what is needed. Spread out the figures on a poster or the wall. Review the figures (feedback) and determine if they are in the right order for your story. Analyze if there are too many or unnecessary figures?
- Present work in a manner that best tells the story – analogy for papers is that you are a lawyer arguing a case... present the witnesses (experiments) to the jury in the most clear and logical order -- one that tells a story. This is not necessarily the order in which you originally interviewed them.

Title - This provides the first impression to the reader, so selecting the most appropriate title requires some thought. The title influences whether a reader is interested in reading the manuscript. It should include all essential words in the right order such that the topic of the manuscript is accurately and fully conveyed (e.g. clearly related to the purpose of the study) (Rudestam and Newton, 1992). Avoid long titles (the recommended length is 10 - 12 words) and those, which begin with redundant words such as "A study of..."

- The Title of the manuscript should be as short and informative as possible. It should not contain non-standard acronyms or abbreviations nor exceed two printed lines. The title page should also give the names of all authors and their complete mailing addresses.
- The title page should also include the name, the telephone and fax numbers, and the E-mail address of the author to whom all correspondence about the manuscript, including proofs, will be sent.
- The Running Title to be printed at the top of each page of a published paper cannot exceed 60 characters and spaces.

Abstract - This will be a brief description of the project and the results. In the abstract you will include the specific aim or purpose of the experiment. The abstract should be less than 200 words. Despite its brevity, all the important results of the work should be noted. *The abstract is sometimes the hardest part to write and I found it is easiest to write it after the rest of the report has been written.*

- First sentence is the question asked with one or two sentences on background if word limit allows (present tense).
- Research approach to answer the question (past tense).
- Most significant findings (past tense).
- Answer the question posed in the beginning of the abstract (present tense).
- If space allows – include a speculation of the implication of the study.

Introduction - The introduction should be a succinct statement of the state of knowledge of the project at the time of its inception, the purpose of the research, and the approaches taken. Write this last as your understanding of where the paper is going will have matured at this point. Also there is no need to introduce what is not discussed. Statements of previous knowledge in the introduction should include supporting citations. Simply put – this is the background section that fills the reader on your protein or system and the current knowledge of the science.

- Past tense for much of the introduction. When discussing established facts, switch to present tense.
- Introduction answers three questions: 1) what is the big picture or question, 2) what is the specific question, 3) what don't we know/how will this study help?
- A clear statement of the hypothesis and main questions early in the introduction will help focus the reader's attention.
- Start with a summary of the subject and literature to provide reviewer enough information to understand the main points of the results and discussion, how these points expand the body of understanding and to allow the reviewer to better understand how the work is worth publishing.
- Second illustrate and introduce what is unknown or problematic. Identify gaps and disclose similar studies to those presented in the MS.
- Close with a clear declarative paragraph of the problem you have answered. Remember your hypothesis and summary questions when writing this paragraph. Include a simple summary of the most important finding(s) of the paper. "...in the current study, we demonstrate that...", "the purpose of this study was...", or "this study was undertaken to..."
- Review your introduction when finished. Does each sentence contribute to the summary statement described above? If not, delete.

Methods - The materials and methods section should succinctly describe how the work was performed. The Methods Section is a critical element of the paper. The methods section will not be a re-write of the instructions of the lab handout. An example of the style of method expected is here:

If for example protein concentration was determined by the Bradford method, you need not write out the method. It would suffice to say "protein was measured by the method of Bradford (2)" with reference to the original protocol. Most times there are small changes and then the method would be written "protein was determined by the method of Bradford (2) with the following changes: ..." or .. by the method of Bradford (2), briefly, 20.0 µl of samples were added to 2 ml of Bradford reagent and the absorbance at 595 nm determined.

This section is not a recipe or a step-by-step description of everything you did. Nor should the methods section be a copy of any handouts. Instead it should give the reader enough information on how you conducted your experiment.

- When describing reactions, assays or buffer composition volumes are rarely used. Instead use the final concentration of a buffer e.g. **BAD**- “we added 10 ml of 1M Tris and adjusted the pH to 7.0 with HCl to make running buffer”. **GOOD**- “ 10 mM Tris-Cl, pH 7.0 (Running Buffer)...”
- When describing a complex mixture, such as a chromatography buffer, list each of the components in the buffer followed by a parenthesis with the abbreviation.
- For each chromatography the writer should include the volume of the column, the inside diameter of a column, the buffer the resin was equilibrated in, flow rates, volumes of wash and elution and fraction size. If the column was run by gravity, then just state that the column was performed by gravity flow. See the JBC handout for examples.
- Be certain to include temperatures, times pH of solutions, incubation times for all methods.
- Generalize - report how procedures were done, not how they were specifically performed on a particular day. For example, report "samples were diluted to a final concentration of 2 mg/ml protein;" don't report that "135 microliters of sample one was diluted with 330 microliters of buffer to make the protein concentration 2 mg/ml." Always think about what would be relevant to an investigator at another institution, working on his/her own project.
- Each technique or experiment will have its' own method. Give each technique – experiment it's own paragraph with a header as seen in the JBC handout.
- **Style** – In the methods section, it is best to avoid first person (i.e. I added two microliters.. We then did...). You will write in a passive past tense voice for most of this section. Doing otherwise would focus the attention on the investigator instead of the method. Avoid lists and recipes and use complete sentences.
 - Pay attention to the Journal's style guide (wrong style can irritate reviewers). Methods must have enough details to allow someone to repeat the experiments.
 - Organize in order of figures/results section. Written in past tense with a passive voice, avoid first person.
 - Often looked at much more closely by editors and reviewers than one might imagine. This section should allow reviewers and readers a clear way to understand how the studies were conducted.
 - Include relevant information on animal and human studies (IRB/UACUC) how subjects were included or excluded.
 - Less information on materials is included than 15 – 20 years ago, but don't forget specific specialized reagents, antibodies, oligo reagents...
 - Avoid referencing methods that are references themselves.
 - Create the section in small segments in a logical order – use subheadings

Results - The results section has the data that were obtained. These results are often shown as graphs or photographs. Do not put in tables of raw data if the report can be better represented as a graph. Tables of data should have a heading or title. Each graph and table will be numbered as Fig 1 or table 1. Try to avoid extensive discussion in the results section.

- This section is used to 1) report results and present how this data supports the hypothesis.
 - Written in past tense with summarizing data in present verb tense. Avoid discussing the findings.
 - Organize the results in the same order as materials section for clear reading – may even use same basic topic sentences or subheadings as in figure legends.
- Do not include the raw data. Do not include tables of data that have been graphed.
- Figures, images and tables should all be included in the body of the paper. If a table is too big then either add a section break in the column format of the paper, or included the table at the end of a paper.
- **Style** – For the results section, use past tense.
 - There is a very straightforward rhythm to the results section. Use the algorithm: because of this (earlier study, data presented in the MS or other's work) we asked this question (sub-hypothesis). To do this we did this... experiment. Follow with description of results with final comment.

As constitutive activation of Erk-MAP kinase has been implicated with upregulation of uPAR in several human tumour types (Hoshino and Kohno, 2000), we investigated whether p42/44 Erk-MAP kinase activity plays a role in the regulation of uPAR expression in HCT116 cells. In vitro kinase assay, specific for p42/ 44 MAP kinase activity, showed approximately two-fold higher MAP kinase activity in WT and mock-transfected HCT116 cell lines compared to A/S cell line (Table 2). British Journal of Cancer (2003) 89, 374 – 384.

Alternative regioisomers 3-chloro-2-aminopyridine and 2-chloro-3-aminopyridine and the more reactive 4-amino-3-bromopyridine also did not couple with borolane 5 beyond 3% yield under these conditions. To eliminate the possibility that ethoxyvinylborolane 5 cannot couple or decomposes under these conditions, it was tested in a reaction with 4-chloroaniline 7, previously shown to couple efficiently with a range of borolanes.(21) This reaction was successful, giving 52% product (entry 1, Table 2). J. Org. Chem., 2010, 75 (1), pp 11–15

- Key transition phrases between data groups include... “Having shown... we next examined / determined, these results suggest that...” Read through accepted MS in the journal you plan to publish in to identify key results words that do not interpret. Examples include: associated, correlated, significantly, apparent, ... having these phrases and words will greatly speed up the writing process.

Discussion - The discussion section is where you talk about the significance of the results. For example, if an experiment failed, you might want to discuss what you think went wrong. The discussion is the appropriate place to go over the theory that is supported by or refuted by your data. Limitations in the data should be clearly noted. This is the appropriate place to answer the purpose of the experiment. If you want to compare four different methods of protein concentration assays, then here is where you would say what you found what it means and any comments for future experiments.

- The purpose of this section is to answer the key questions from the hypothesis, fit the findings with existing knowledge, and convince the reader/reviewer with the approach and limitations of the results.
- Compare your results to other similar projects (this might be difficult for your paper – but, look up other MDH purification papers for comparison – this is required). DON'T forget to reference accordingly
- Finish with a paragraph that discusses the future avenues of research. For this paper – you must include what you will do with the protein now that you've purified it. Be creative here...
- DO NOT BE SUPERFICIAL in your discussion or simply restate the results.
- **Style** – In the discussion section, refer to your studies in the present tense and other data in the past tense. When referring to commonly accepted scientific facts or widely known observations/behaviors, use the present tense.
 - Written in present tense and is often written in the active voice.
 - Start with a paragraph reviewing main thrust of results – highlighting only the most key points. Keep in mind the summary statements. Clearly write how this study answered these questions and the degree that the described work advances the state of knowledge. Finish the initial paragraph with a clear statement indicating the significance of the MS. This paragraph should only be a few sentences long.
 - Identify the main results from each section of the results and figures – then add in causality. i.e. find a mechanism to explain/interpret the results.
 - Do not overstate the significance or novelty. Use terms and phrases such as: “probably”, “is likely”, “one possible interpretation is...” to avoid sweeping or overly enthusiastic conclusions.
 - Discussion words (different from results words): those that infer mechanistic causes and effects from data presented in the results section: “influences, sufficient, necessary, associated can be used if needed to soften if the link between cause and effect are less clear.
 - Overall flow of discussion: opening paragraph, explain results, indicate originality and importance of study, discuss unexplained or expected findings and how findings concur with others.
 - **Concluding paragraph**: restate logical conclusions and why the study is relevant. Then add how further studies could further your work or substantiate the findings of the MS

Reference – You will reference according to the journal style of your advisor's preference.

Each main declarative sentence should be referenced. DO NOT reference a website (without approving by your research advisor).

Finally: As you get to the summary statements, finish the figures, complete the results section work through the discussion and create the final conclusion paragraph, review the data to see if the data, results and discussion all point to the main hypothesis. Does this story still match your summary statements? Review and revise to keep a clear story. This is especially important for when a MS is written in the middle of many distractions a semester will bring.

References:

- Algorithm for writing a scientific manuscript. O'Connor and Holmquist. Biochemistry and Molecular Biology Education. Vol 37, pp. 344–348. 2009
- Ten principles to improve the likelihood of publication of a scientific manuscript. Provenzale. American Journal of Roentgenology. 188, May 2007
- An approach to the writing of a scientific manuscript. Cetin and Hackam. Journal of Surgical Research Vol 128, 165–167. 2005
- Writing readable prose. Brendan and van Roy. EMBO reports Vol 7, 846. 2006
- Writing a scientific manuscript. Highlights for success. Spector. J Chem Ed. Vol 71, 47. 1994