Appendix B: Scientific Writing & Presentation of Scientific Findings

Introduction

Findings or results from an experiment are usually communicated in verbal or written formats. Most of the writing done in science is in the form of research proposals, journal articles or lab reports, lab notebook entries, and presentation proposals. Oral presentations are also common in the scientific field in order to share and corroborate findings. In this course, you will have the opportunity to practice various scientific communication genres. The following information will help you successfully accomplish these tasks.

Writing a Research Proposal

If you are designing your own experiment or proposing a study, it is very likely that you will have to write a research proposal beforehand. The purpose is for you to carefully work out all the details of the experiment or study before you do it. You might also have to get the proposal approved by your laboratory instructor.

How do you write the research proposal?
Answer the questions on this page. Then follow the directions for turning your answers into a proposal. You may answer these questions on a separate sheet of paper or use a word-processing program.

1. What is the problem? Describe the problem in your own words. Be sure that your description includes known factors (information about the problem given to you in the laboratory in a problem statement, for example) and unknowns (what you need to find out in order to solve the problem). Then restate the problem in the form of a question or questions.

2. What do you know about the science of the problem that could help you answer your research question? Write down everything you can find about the topic or scientific concept that might be useful in answering the questions you have. Remember to note any references you use so that you can cite them in the proposal.

3. What is your hypothesis for the answer to your research question? Using what you know about the problem and the scientific concept, state a hypothesis, your best estimation of the answer to your research question. Then describe the reasoning that led you to your hypothesis.

4. What variables can you use to test your hypothesis? A well-designed experiment needs to have variables. Look over your hypothesis and identify the variables that you will be testing during your experiment (see Appendix E for help with variables). What can you measure or observe (dependent variables) and what can you manipulate in an experiment for the measurements or observations (independent variables)? List your variables. Then describe, in words or in a sketch, the relationship among the variables as predicted by the hypothesis.

5. What experiment(s) could you use to test your hypothesis? Referring to the list of variables, brainstorm some experiments you could do that would allow you to manipulate variables so that you can make the measurements or observations necessary for testing the hypothesis. Your experiment may require control and treatment groups.

Choose the experiment most likely to yield the results you need to test your hypothesis. List the materials and outline the methods you will use for your experiment.

Turning Your Answers into a Research Proposal

Step 1. Arrange the answers under three headings:

Scientific Background
Answer to question 2

Research Problem
Answer to question 1

Research Design
Answer to question 3
Answer to question 4
Answer to question 5

Step 2. Rewrite your answers so that they sound more like a formal proposal. Follow this general advice:

1. Revise the paragraphs so that each paragraph is about a single, focused topic. In the draft you have created from your answers you may have put all the information from each answer in a single paragraph. Read your answers and pick out the main ideas in them that could become separate paragraphs.
2. The language of the proposal should be relatively formal. The answers to your questions are probably in relatively casual language, more like everyday speech than formal writing. As you reread your answers, notice the places that do not sound like formal scientific language and rewrite them so that they do.
3. The language of the proposal should be relatively objective. In your answers you most likely put yourself into your writing, using a lot of "I's" or "we's" or other terms that refer to yourself. In the research proposal, you should use those references sparingly. This is primarily because in most scientific writing the focus is on the science rather than the

scientist. One way to make this revision is to change active voice ("I will train the participants") to passive voice ("The participants will be trained"). Passive voice is often considered appropriate when describing an experiment.

Writing a Successful Lab Report

Lab report writing will help you practice many of the skills associated with authentic scientific practice, because lab reports follow the scientific process and allow you to communicate your results using scientific discourse. To write your lab reports, you may refer to LabWrite (http://labwrite.ncsu.edu), an on-line tutorial. LabWrite is available as static web pages as well as an interactive format called "Tutor," which allows you to write your lab reports on-line. LabWrite guides you through the entire lab experience, from before you complete your laboratory to after you have turned in your report, whether the lab is hypothesis-driven, descriptive, or designed by you.

Using the "Inside-Out" Approach to Writing Lab Reports

Although lab reports are structured in a specific order, scientists do not usually write their papers in that order. They start with the sections with which they are most familiar after conducting an experiment: Methods and Results. From there, the writer can easily move out to the remaining sections of the report. Below is a "Quick Guide" to writing lab reports. Use it as a quick reference, but please make sure to visit the web site above to obtain the full benefits of the tutorial. Also, make sure to visit LabWrite Resources, where you will find help for all kinds of tasks commonly used in science: basic data input, graphing, table design, determining types of data, determining types of graphs, sample lab reports, and many more.

Please be certain that all lab reports are typed, double-spaced, and turned in on the indicated dates. If you have any questions, be sure to check with your laboratory instructor before submitting your work. Also note that the sections you may be asked to include in your lab report can vary from the standard list in the following "Quick Guide."

Quick Guide to Writing Your Lab Report

Methods: Describing the laboratory procedure

Using your laboratory manual, handouts, and notes taken during the laboratory as a guide, describe in paragraph form the experimental procedure you followed. Be sure to include enough detail about the materials and methods you used so that someone else could repeat your procedure.

Tips on writing the Methods:

- Describe the experimental procedure you followed in paragraph form.
- Review directions in the laboratory manual and your notes taken during the laboratory.
- Include enough detail for someone else to repeat your procedure.
- Describe the procedure clearly.
- Describe what you actually did, even though it may be different from the ideal procedure in the manual.
- Avoid putting results in the Methods section.
- Write one paragraph for simple labs, multiple paragraphs for complex labs.

- Write in past tense.

Results: Making sense of your data for yourself and others

Step 1: Create appropriate tables, graphs, and other figures to enable you to visualize your lab data.

Step 2: Decide the order in which your tables, graphs, or other figures should be presented in the Results section.

Step 3: Review all the data from your experiment. In a sentence or two summarize the main finding of this lab.

Step 4: In separate paragraphs, summarize the findings in each of your visuals, tables, graphs, or other figures. Each paragraph has two parts: (1) the overall relationship or interaction among variables represented by the visual; (2) key details from the visual that are important to understanding the experiment.

Step 5: Place all the elements you've written in the proper order.

Introduction: Establishing a context for the lab

Step 1: Clearly state the scientific concept and information about the scientific concept related specifically to this laboratory.

Step 2: Write how achievement of the main objectives of the lab helped you learn about the scientific concept of the laboratory.

Step 3: State your hypothesis clearly. Based on the scientific concept of the lab, rewrite the explanation for your hypothesis.

More tips on writing the Introduction:

- Ensure that your Introduction establishes a context for the rest of the lab report; a way of understanding its significance.
- Focus your Introduction on information about the concept that is most clearly related to the lab procedure.
- You may need more than one paragraph.
- If your report is more like a full scientific paper, you may need to do more research using the Internet and the library. Search the recent scientific literature. Summarize that research in a paragraph, stating the general findings, and use those findings to describe the current knowledge in the area. Cite your references.
- Use background material about the scientific concept of the laboratory to explain your reasoning for the hypothesis even if your hypothesis was not supported by your data.
- Verb tense is a little tricky in this part of the report. When talking about the experiment itself, such as when you are addressing the objectives of the laboratory and the hypothesis, use past

tense. But when you are talking about broader issues, such as the learning context and the purpose of the lab, use the present tense. When you are referring to sources, such as the laboratory manual, textbook, or scientific articles, uses present tense.

Discussion: Interpreting the results of the lab

Step 1: State whether the results from the laboratory procedure support your hypothesis.

Step 2: Identify specific data from your laboratory that led you to either support or reject your hypothesis. Refer to the visual representations of your data as evidence to back up your judgment about the hypothesis.

Step 3: Using your understanding of the scientific concept of this lab, explain why the results did or did not support your hypothesis.

Step 4: Additional discussion: (1) problems or sources of uncertainty in laboratory procedure; (2) how your findings compare to other students'; (3) suggestions for improving the laboratory.

Tips on writing the Discussion:

- It is not considered a failure if your data does not support your hypothesis. Failure to support hypotheses is common in science.
- Back up the statement about the hypothesis with direct evidence from the laboratory data that supports, does not support, or partially supports the hypothesis.
- Experimental science is about testing hypotheses. You, as a scientist, must be unbiased and objective.
- Do not introduce any new findings that are not presented in the Results.
- Do not put detailed analysis of graphs, tables, and drawings in the Discussion. The analysis belongs in Results.
- Use the past tense when referring to what has been done in the experiment, but use present tense when talking about most everything else, such as scientific concepts, explanations, and references to articles.

Conclusion: Focusing on what you learned by doing the laboratory

Step 1: Write a paragraph summarizing what you have learned about the scientific concept from doing the laboratory. Back up your statement with details from your laboratory experience.

Step 2: In a second paragraph, describe anything else you learned from doing the laboratory.

Abstract: Summarizing the lab report

Step 1: Summarize each major section of the laboratory report, Introduction, Methods, Results, Discussion, and Conclusion, in one sentence each. You may need two if a section is complex. Then string the summaries together in a block paragraph in the order the sections come in the final report.

- Introduction: main objective(s) of the laboratory; hypothesis
- Methods: a quick description of the procedure
- Results: statement of the overall findings
- Discussion: judgment about hypothesis; explanation for judgment
- Conclusion: what you learned about the scientific concept

Title: Capturing the essence of the report

Write a title that captures what is important about the laboratory, including the scientific concept the laboratory is about and variables involved, the procedure, or anything else that is important to understanding what this report is about.

Tips on creating a good Title:
- The title captures what is important about the laboratory, including the scientific concept and variables involved.
- A title should use the fewest possible words to adequately describe the content of the report.
- A title should be as specific as possible. Specify the primary focus of the experiment.
- Do not write the title as a complete sentence, with a subject and a verb. Titles are only labels.
- Do not use catchy titles. This is not an English paper or an editorial.

References: Acknowledging sources of information

List all the sources you referred to in writing the report, such as the laboratory manual, a textbook, a course packet, or scientific articles. Be sure to use the proper form of documentation for the scientific field you are working in. Ask your laboratory instructor if you are not sure of the proper form.

Tips on writing the References section of your lab report:
- The References section is a bibliography listing all the sources you used in writing your lab report, such as the laboratory manual, textbook, course packet, or scientific article.
- Use the proper form of documentation for the scientific field you are working in. Check with your laboratory instructor.
    - Find out what form of documentation is appropriate to use in your class before you write your first report. T he best place to look is the laboratory manual.
    - Different scientific fields use different styles for documenting sources in the References. The Council of Biological Editors (CBE) style is used in the life sciences. See examples below:

Book:
Campbell, N.A., J.B. Reece, and L.G. Mitchell. 2002. Biology, sixth edition. Addison Wesley Longman, Menlo, CA.

Journal article:
Borgnia M, Nielsen S, Engel A, Agre P. 1999. Cellular and molecular biology of aquaporin water

channels. Annual Reviews in Biochemistry 68:425.

NOTE: Research proposal and laboratory report guidelines were written with materials taken from the LabWrite Project©, produced at NCSU, funded by the National Science Foundation, 2000-2007.

Oral Presentation Guidelines

1. General hints:

a. *Remember that oral and written forms of communication are different*. When you write a paper, everything is right there for the reader to read at his/her own pace. If the reader misses something, he/she can just go back and re-read. Oral presentations, on the other hand, don't give the audience—the listener—time to look back at information that was not clear. For this reason, focus on key material and keep it simple, be concise, be organized, and ask yourself whether or not someone seeing your presentation for the first, and probably only time would be able to understand it. Before you get started, tell your audience what they can expect to get out of your presentation. At the end, provide a brief summary.

b. *Prepare your presentation for the type of audience you expect.* More often than not, you will know ahead of time who your audience will be. This gives you an opportunity to structure your presentation accordingly. If your audience is made up of experts in your field, then perhaps you need more detail and less basic background. If your audience is made up of people who know little to nothing about your topic or field of expertise, then provide less detail and more general background. If it is a mixed audience, you need to find a balance so that you don't bore the experts or overwhelm the novices. For any audience, think about how much content people will remember from your talk in a few hours or a few days later. Emphasize what you want them to remember.

c. *Rehearse:* It's important that you time yourself so that you fall within appointed time constraints. Also, things are a lot different when you are facing a crowd, so recruit some friends when rehearsing.

d. *Be professional:* Use professional language, no slang; and dress nicely (no bright colors, flashy jewelry, or hats, which may distract the audience from your presentation).

e. *Provide a question and answer period at the end of your talk:* Allocate a few minutes to answering questions. You may also use this time to involve the audience by asking their opinions, experiences, or other questions.

2. Hints on using PowerPoint® for presentations:

a. *Rule-of-thumb, "less is more:"* Your slides need to be clear and uncluttered so that the listener can digest the information on the slide in a very short period of time. Do not

include too much text. The slide is there to provide key points, and you, the speaker, will fill in the details. In other words, do not read your slides to your audience.

b. *Pick your slides wisely*: The slides you include should support the goal of your presentation. For example, if the goal is to show the findings of an experiment, then you should provide the experimental design, the hypothesis, methodology, findings, conclusions, etc.

c. *Title your slides clearly:* Don't use a full sentence for a title. The titles of your slides should say what you are about to describe or explain.

d. *Use the same font for each slide:* Using different fonts makes your presentation look less coherent and unpolished.

e. *Use the same font size for all bullet points on one level:* For example, level a-c should all have the same font and font size. Level one-three should all have the same font and font size, etc. Although font sizes are usually set automatically, make sure that your

font size is adequate for the size of the room and the distance of the audience from your presentation.

- Level a
    - Level one
- Level b
    - Level two
- Level c
    - Level three

f. *Use the same background color scheme for every slide in your presentation:* An exception to this would be a photograph or other image, which wouldn't fit in with the slide color scheme or layout.

g. *Label graphs properly and make them large enough to see:* Graphs should be labeled with a title (above the graph), axes titles (on the x- and y-axes), and a legend outside the body of the graph. All text on a graph should be clearly legible and easily seen from a distance. Test this by trying to read your graphs from a distance. Usually, figure numbers are not necessary in a presentation, unless the audience has a copy of the presentation, and you will be referring to figures by numbers during the presentation.

h. *Other helpful hints about graphs*:

1. Don't use a border around your graph or grid lines, unless you need them for some reason. Label your points on the x- and y- axis so that they are not cluttered and they are easy to read (again check font size). Your axes titles should not overlap with the axes point labels. The axes titles should be parallel with the axis.

2. Do not include raw data or a spreadsheet with your graph.

3. Avoid three dimensional effects, as these could confuse the data.

4. Use a scale that is suitable to your data. If you are plotting very small numbers, use a scale that is appropriate. Using the wrong scale can make your data look incorrect.

5. Make sure that, if using line graphs, the lines are easily distinguishable from each other. If using bar graphs, there should be a space between each bar (or clusters of bars) at a data point.

6. Graph titles should provide information about the relationship between the variables you observed.

7. Make sure that graphs and other figures are not pixilated.

i. *Choose color combinations wisely:* Avoid colors that have a high contrast. For example, bad combinations would be a lime background with purple, pink, red font (or vice-versa); or blue with red or dark pink font (or vice-versa). In general, avoid bright colors that can distract the audience or make it difficult for them to see what is really important in the slide. Usually, a white background (or off-white, cream, or other light neutral) works very nicely with black or another dark color. You may also use a dark blue with white font (or off-white, cream, or other light neutral font). Keep in mind that what looks pretty on your computer screen doesn't always look the same once you project it in a large room.

j. *Slide background scheme:* Choose a background that will not interfere with text or figures that are in your presentation. A forest or ocean background may be nice to look at, but it may make it very difficult to see a graph or even read the text on the slide. Also, if you do pick a background scheme, make sure that it matches the theme of your presentation. Don't use a heading banner with a DNA molecule if you're doing a presentation on predatory behaviors of tigers, for example.

k. *Give credit for images that are not your own:* In small font, provide the source for the image.

3. General outline for a presentation of a study or experimental findings (may be modified for other formats):

- **Title/author(s)/school** (1 slide)

- **Key topics/objectives for the presentation** (1 slide)
  This serves as the "abstract" for the presentation

- **Background**
  - **Material that is needed for the audience to understand your topic** (1-several slides may be needed)
    For example, if you are talking about specific freshwater fish, you may want to list each one and provide some information about basic behaviors, habitats, and other relevant information. Also, it is a good idea to include species names whenever you are talking about an organism (remember to capitalize the genus only and italicize or underline the entire name, e.g., *Homo sapiens.*)

  - **Purpose** (1-2 slides)
    Why should anyone care? Why did you do what you did?

  - **Related Work** (0-1 slides)
    You may want to tie in your work with other similar work in your field.

  - **Hypotheses or research questions** (1 slide)

- **Methods (**1-2 slides) (include experimental design here too; what was done or what is proposed)

- **Results or Findings** (number of slides will vary)
  Present key results and observations. This is the core of your presentation. It should include supporting data tables (tables should not have too many data points), graphs, and other pertinent figures. Unless your raw data table or spreadsheet is special, e.g., because it illustrates a unique way of collecting data, leave it out of your results. Be thorough in your presentation of results, do not just present numbers, interpret them and elaborate on the relationship between variables.
- **Conclusion** (1-2 slides)
- Wrap up your presentation by stating what you learned from doing the experiment—what do the data show and why they are important. This is where you present the "big picture" and how it all ties back to other findings in the field and to your hypothesis or research questions.
- **Limitations to your study** (0-2 slides).
- Discuss sources of error, or things you would have done differently if you could.
- **Summary** (1 slide)
- **Future Work** (0-1 slide)
  Give problems this experiment opens up.
- **Backup Slides**
  Always have backup when relying on electronic formats.