Appendix A: Scientific Writing

Effective writing is as important in the sciences as it is in the humanities. Among the most important skills you can learn in college are the development of logical and creative ideas and the clear, accurate, and concise communication of those ideas. Like any effective writing, good scientific writing must be precisely organized in a clear and informative manner. Cumbersome, confusing, or tedious prose has no place in scientific writing. Good scientific writing takes complex ideas and data and translates them into illuminating prose that has grace and elegance; the intention is to inform the reader and craft a report or paper that excites and motivates.

General Instructions

Your reports are to be typed, double-spaced, in 12 point font. There must be one-inch margins on each page. Use proper typography throughout your report, including superscripts and subscripts, and italicized organism names. Figures and graphs should be electronically pasted into the text, rather than appearing as separate pages at the end of the report.

Lab reports must be submitted in your portfolio, which is a three-ring notebook containing your cumulative work in this course and subsequent Biology courses. Do not use plastic page covers. Do use dividers to organize the portfolio. Proofread all of your work! A sloppy report or portfolio leaves a poor impression of your work.

Use vocabulary appropriately. Technical words should be used only when they clearly communicate a concept that would require a lengthy explanation in plain English (ex., transpiration instead of "the movement of water through plants from the roots, up the stem, and out through the leaves"). Do not use contractions. You should use the past tense in the methods and results sections. The introduction should be written in the present tense. Each major section (Introduction, Methods and Experimental Design, Results, Discussion) should have its own heading. When you finish one section, start the next section there, not on a separate sheet of paper.

Title

Each report requires a descriptive title. Usually, this title, along with the student name and lab section, are placed at the top of the first page, rather than on a separate title page. The title identifies the important content and orientation of the report. Avoid vague or generalized titles. Do not use the title in your lab manual, ex., "Plant Hormones", since your report probably is not covering the entire field of plant hormones. Do not be overly creative either, ex., "Three Little Hormones, or How My Plants Grew". Instead, find a title that will accurately describe the contents, ex., "The Effects of Three Common Plant Hormones on Pea Seedling Development". If your report is relatively simple, you might want to use a title like "The Concentration of Sucrose in Unknown #5 is 7.3%". Write the title after you have completed a draft of the other sections.

Introduction

Background. Begin your lab report by explaining the subject of the report to the reader. Define your subject area, explain why it is worth considering, define any key terms (what is osmosis?), and give a general overview statement of your purpose. Your textbook and lab manual would be a good source for background information, but remember not to copy text from any source without attribution.

Do not use comments like "It is important for all students to increase their understanding of the fundamental and important principles of diffusion and osmosis because life would not be possible without them." This sentence (from an Biology 107 lab report, Fall, 1999) adds nothing to the introduction.

Hypothesis or Question. This is the heart of your paper--what are you attempting to find out? Your entire paper should be framed around your hypotheses or questions. A good hypothesis states that a specific result should occur given a specific set of circumstances, and should have a reason why you so predict. For example, "Cut flowers placed in an empty vase will wilt, because they will be transpiring water without being able to replace the water they lose" is much better then "Cut flowers usually wilt because Mother Nature doesn't like them being cut". Writing a good hypothesis is not easy, but it is a great opportunity to show you understand the lab.

Methods and Experimental Design

This section explains and justifies your procedures with enough detail so your work could be repeated. Link your methods to your hypotheses ("The rate of osmosis was measured for each solution by examining the gain in mass over time.") This section should include how you collected any measurements, what controls you used, the independent variables you manipulated, the dependent variables you measured, the fixed variables you controlled, and important materials or equipment used. Any calculations or statistical tests should be described.

The methods section should not be written "cookbook" style (ex., to AVOID: "First you cut the flower. Then you place it in a stopper. Then you put the stopper in a vase. Be careful not to leave an air bubble"). This section must be written in past tense, passive voice.

Examples:

Active: We placed 1 ml of water in each tube.

Passive: 1 ml of water was placed in each tube.

Results

Text. This section should report the results of each experiment, and should refer to tables of data and graphs as appropriate. Results must be described in prose, graphs and tables alone are not sufficient. It must be written in past tense, and don't be afraid to use the first person. ex., "I found that white pine trees transpire 38% more water than do sagebrush plants of the equivalent biomass". The important thing about this section is that it summarizes your data and clearly indicates the important points about your data that you want the reader to know. This is normally the place where statistical analyses of your data are presented. Each table and graph should be numbered (e.g. Figure 1, Figure 2, Table 1, Table 2, etc.), and each should be cited at least once in the results If it is important enough to create, it is important enough to refer to. "Peas grown in high-nitrogen soils grew 2.5m, but peas in low-nitrogen soils only grew 1.8m (Figure 1)" is much more appropriate than "The results are in Figure 1". This section should not explain or interpret the results! That is the task of the discussion.

Figures. Tables and graphs should be numbered, and should have a caption, so that the figure is understandable without needing to read the text. Be sure that each type of data has the proper scientific units stated (e.g. cm/minute). For graphs, the independent variable should be assigned to the ***x***, or horizontal axis. The dependent variable should be assigned to the ***y*** axis. Be sure to give each axis a title. For example, if you wanted to graph the length of a leaf you measured each week for 3 months, the weeks are the independent variable, and should be assigned the ***x*** axis, and the length is the dependent variable, and should be assigned to the ***y*** axis. Look at your graphs to make sure you have not repeated any of the errors from the Graph Analysis Worksheet. Tables and graphs should not run over multiple pages, and should be electronically pasted into the text, rather than appearing at the end of the report.

Discussion

The discussion section is where results are interpreted and explained, in the light of the hypotheses. So you

found that plants were more elongated with hormone X than with hormone Y? What does this mean? What does it do to your hypotheses? Support them? Deny them? What problems did you have? What are the potential sources of error? What new ideas do you have for further research? Do not simply reiterate the data from the results section; rather, use this section to describe what conclusions about your hypotheses you believe can be drawn from the results. This is the place for developing new theories or hypotheses. ex., "Although I proposed that sagebrush would transpire more than white pines, this hypothesis must be rejected. Rather, I propose that sagebrush are more efficient at sensing soil moisture levels, and reduce transpiration by closing their stomata when water is hard to obtain." Remember that whatever new hypotheses you propose must also be testable and falsifiable. This is also the place to discuss any errors that might have affected your results. Note: do NOT say "There were many possible sources of error in this experiment." Be specific, ex., "I did not record seedling growth between October 15 and October 18. Because most of the changes in growth occurred between these dates, my ability to explain these changes is limited." or "A giant meteorite from space crashed through the stratosphere and struck the earth exactly in the middle of my laboratory bench, breaking three dialysis tubes, and limiting by ability to estimate the concentration of the unknown."

Citing References

When you use ideas or direct quotations from another source, you should refer to the source. References make your lab report more complete. You should enclose quoted material in quotation marks (" "). Paraphrased material does not need quotation marks, but must be cited. In either case, follow the source material with a reference in parentheses. If the source is a book, you should include page number(s).

Example

It has been reported that the grass is greener on the other side of the fence (Jones, 2002, pp. 486-490).

Place the complete reference for the book or journal article at the end of your report.

Specific Tips

Use good writing style. This requires organization, planning and revision. Outline your report, focus on one idea per paragraph, use topic sentences, and support your ideas with specific examples. When you finish reread for style, and revise any sections that need it.

The most common usage errors occur when students misuse the related words less/fewer and affect/effect. Use "less" when referring to a continuous quantity, like water. Use "fewer" when referring to a discrete unit, like people. You cannot have "less people"! In scientific writing, use affect as a verb, and effect as a noun.

The scientific names of organisms must be italicized, with the genus capitalized and the species in lower case. Ex . *Escherichia coli*. To italicize in Microsoft word, press the control and "I" keys together, and then type the words to be italicized. To exit italics mode, press the control and "I" keys a second time.

When writing scientific reports for Biology 107 (and for many other classes) you will need to use superscripts and subscripts in molecular formulae, to represent exponents, and for other reasons. If you are using recent versions of Microsoft Word, you can press the Control/Shift/+ keys together to activate superscript mode. Then type the text you would like to superscript. Press the same three keys together to exit superscript mode. Pressing the Control/+ keys together activates and deactivates subscript mode. If you have a different word processor, consult your manual or help screen for instructions. Do not handwrite superscripts and subscripts in your lab report.

Common Errors

These examples of common errors have been drawn from previous freshman lab reports. (We DID NOT invent them.) The students were experimenting with strength and absorbance properties of paper towels.

1. ***"Maybe seeming if there are different fabrics added to certain towels or something along those lines."*** This is a sentence fragment, which cannot be understood. Did the author proofread the report or just print it immediately after composing it?

2. ***"After we did that we poured lead weights on until the paper towel would break. We had to make sure that we weighed the bowel that the lead fell into so we could subtract that from our total from the lead that we poured on to the paper towel. Then we would weight the bowel and the amount of lead we poured on the paper towel. We did this three times with each paper towel brand."*** Proofreading would have caught "bowel" when obviously "bowl" was intended. "Would break" is the wrong verb tense and the sentences are snarled with unnecessary information. An edited version might say: "We poured lead weights onto the paper towel until it broke. We weighed the collection bowl and subtracted that weight from our total of lead plus bowl. We repeated this procedure three times with each brand of towel." Better editing produces: "We poured lead weights onto the paper towel until it broke. We weighed the lead required to break each sample and repeated the procedure three times with each brand of towel."

3. ***"Hypothesizing the outcome of the test we figured if Bounty was the strongest then it would have the highest mean tensile strength."*** This sentence contains several problems. "We figured" is not scientific terminology and should be replaced by "we hypothesized." The word "strongest" has not been defined. Also, two commas are missing. Edited version: "We hypothesized that Bounty would have the highest mean tensile strength."

4. What is wrong with this table?

	Weights		
Test	Wet Weight	Dry Weight	
1	6.4	1.2	5.2
2	7.4	1.9	5.5
3	5.2	1.1	4.1

a. The title does not tell us what was done in the experiment. A proper title could be "Weight of Water Absorbed by Paper Towels in Thirty Seconds."

b. There is no unit designated so we might be weighing grams, kilograms, ounces, etc. The second column should read "Wet Weight, grams" or there should be an abbreviation "g" next to the weights: 6.4 g

c. Column four has no title. Subtraction of dry weight from wet weight produces the mass of water absorbed. It should read "Water absorbed."

d. There are no descriptive statistics for this table. A list of values cannot be compared to another list unless a mean and standard deviation are calculated. This table might be used to collect raw data during the experiment, but it contains unnecessary information for inclusion in a report. The important fact concerning water absorbed should be reported as follows: Average Weight of Water Absorbed by Paper Towels in Thirty Seconds: 4.9 g +/- 0.7.

* The calculated mean and standard deviation are reported to the same decimal figures as the original measurements. The balance used measured one decimal place. To give calculated standard deviation values with six figures to the right of the decimal point implies a precision that is not possible in this experiment.

5. ***"Their was no difference in the average whether we used our calculator or there calculator. "***

"We wondered what kind of an affect we could produce if we poured water on the sample first. We were worried about whether the hot or cold water would effect the experiment so we used both."

If you have any questions about proper word usage, use the dictionary! The words their/there and affect/effect are used incorrectly in the above sentences.

6. ***"We could have used only one control, so our hypothesis was not wrong, but using two controls we saw more things and possibilities and learned by disproving a part of our hypothesis."***

What is this person talking about?

Be careful when you write your lab report. Proofread and use common sense. Do not wait until the last minute to print your report. Disk or printer errors are common and could cause your report to be late.