

APPENDIX V: WRITING A LAB REPORT

Lab reports, like journal articles, communicate your work to others and help you to organize and analyze your data. Scientific journal articles have a particular form - **IMRAD** or Introduction, Methods, Results, and Discussion. Read the following information pertaining to writing a lab report both **before you begin writing and after you have completed your first draft** to ensure you have followed the directions correctly. At the end of this Appendix, a very abbreviated **sample report** is given for your reference.

General Requirements

1. **Each student will hand in his/her own report. The only item(s) that will be similar between partner reports will be the data because each of you worked on collecting the same data. The assumption is made that each student has read and understands the student handbook pages regarding what is and what is not PLAGERISM.** You must ask yourself "What is the probability that two people sitting at two different computers in the same room, without discussing the material at the time of typing, will come up with identical reports?" The answer is - improbable. You may, and are encouraged, to discuss the lab results prior to leaving the lab. You may even discuss the results after your lab, prior to typing your report. You may NOT however, discuss wording or outcomes as you are typing your report. That is **your work**.
2. Your report must be **TYPED, DOUBLE SPACED** (except title and literature cited sections), with **1.0 inch margins**. All section headings should be typed in all capitals. Indent each new paragraph, rather than skipping two more lines. All papers will contain excellent **SPELLING** and **GRAMMAR**. Numerical values less than one will be reported with a zero in front of the decimal point (example: 0.2 grams). Always report numerical values in metric units. Please **STAPLE** in the **UPPER LEFT** corner of the paper.
3. Make sure to make backup files and do not wait until the last minute to write your report. "The computer ate it" is **not an acceptable excuse** for not submitting your report on time. However, if for any reason **events beyond your control** prevent you from handing in a report, please see the instructor as soon as possible.

(Specific Instructions)

TITLE

TITLE GOES HERE IN ALL CAPS (*GENUS* AND *SPECIES* NAMES ARE CAPITALIZED AND ITALICIZED), SINGLE SPACED, AND CENTERED. IT SHOULD BE COMPREHENSIVE, SO THAT THE READER KNOWS EXACTLY WHAT THE REPORT IS ABOUT.

Place your name here e.g.: Jane Studios
Partner's Name goes here
Course and Lab section go next e.g. Biology 101, Sec 002
Instructor's name
Date Due e.g.: 30 September 2001

ABSTRACT

The abstract is a short paragraph (usually less than 200 words) that *summarizes* the (1) objectives and scope, (2) methodology, (3) data, and (4) conclusions. This section should be written last, once all of the other sections have been written. Some bibliographic databases only include the abstract, not the entire article, so this information is essential when other investigators are trying to judge the applicability of your work to their current research.

INTRODUCTION

In this section, you will introduce the experiment by explaining generally **what you did** and **why you did it**. This section usually starts with an examination of the literature through a library search to inform the reader about work already done on this topic. If you have never done a bibliographic database search for scientific journal articles, then you are not yet a biological sciences major (note: Google is not a scientific database. If you **MUST** use it, use Google Scholar – better yet, go to a real scientific database through Booth Library's Home Page). Use author/year format, not footnotes) for citations.

The introduction then describes how your hypothesis was developed and then explicitly states the hypothesis. The difficult part of the introduction is to remember to include the specifics, but not to give too much detail. The detailed information will be included in later sections.

MATERIALS AND METHODS

Do not make this section a list of materials and then a paragraph about what you did. Rather, include materials in the paragraphs, as you needed them. Make sure you use **PAST TENSE** and that you are using **PASSIVE VOICE**, not an active voice. Example of active voice: "I added 5 ml of diluted BioRad dye to each test tube...". Example of passive voice: "Five ml of diluted BioRad dye was added to each test tube...". Keep all information in this section as **concise** as possible. You need to realize that the lab instructor who will read this report has a basic understanding of the techniques. You do not need to explain how to use the equipment or

how to do simple tasks (except when you have invented a new method or apparatus). You need to mention only what another scientist (the term used is “someone generally skilled in the art”) would need to know in order to produce similar results. Think of everything that you used in your experiment. Ask yourself "if I changed this, would the results be different?" If the answer is yes, then it must be included in the methods. If the answer is no, leave it out. For example, if you are centrifuging something for 10 minutes, and you use a timer, it would be important to mention *how long* you centrifuged samples, but *not how* you kept time. If you used crushed ice instead of a freezer block to keep samples cool, it would only be important to mention that the samples were kept at a particular temperature, *not how* they were kept that way. Remember to include ALL units, volumes, times etc. in this section. Keep in mind that a scientific paper is NOT a lab report.

RESULTS

There are two parts to a results section: a **Narrative**, and **Tables and Figures**. An explanation of both follows:

Narrative

This section is where you **clearly, completely, and concisely** report your data and explain what it is that you want the reader to notice about your findings. **Do not draw any conclusions** from these findings; that will be done in the Discussion section. When taking multiple data sets, you will summarize your data by reporting statistical parameters such as means (averages), range, standard deviations, sample sizes, and results of statistical tests (if applicable). Remember to explain what the numbers represent. If you are reporting a mean, state that your numbers represent a mean value. If your numbers represent one of two trials, state which trial. All measurements will be metric units. You must **reference all tables and figures** in the narrative part of the results section. Here are two examples of how to reference tables and figures:

"Figure 1 indicates the dramatic difference in the growth rates between the experimental and control groups..." or "The mean growth rate, final mean root length and the mean day of germination were all lower for the experimental seeds than the control seeds (Table1)."

Tables and Figures: General Information

Not all data needs to be reported in a table or figure. Some data can be summarized in the text in one or two sentences (statistical data, for instance). Remember to **title** and **number** all tables and figures. Titles will be self explanatory and complete. Describe the graph/table in words (sample sizes (n) and scientific names will be included). **Raw data is NEVER included** in the Tables and Figures. Treatments, means, ranges and standard deviations are the appropriate numbers to summarize. Tables and Figures are numbered independently. If you have a Table followed by a Figure, then a second table followed by a second figure, the headings will be TABLE 1, FIGURE 1, TABLE 2, FIGURE 2, etc. All Tables and Figures will be presented in the order in which they were introduced in the narrative.

Figures

Figures include graphs, pictures and diagrams. **The legend (title) is placed BELOW the figure.** Start the legend with the word "FIGURE" written in all Caps and left aligned. This format will be followed with the appropriate figure number, then a period. A description of the figure follows with only the first letter of the first word capitalized. Additional sentences may be needed and will be left aligned as well.

Axes on graphs will be labeled and have appropriate units in parentheses. All labels will be centered on each axis and written parallel to the axis. **The independent variable will be on the x-axis, and the dependent variable will be on the y-axis.**

The types of graph you will use in this course are line graphs and bar graphs (or histograms). Each of these types of graphs has advantages in terms of what they represent. Bar graphs can compare absolute quantities between groups rather clearly, while line graphs can give the reader an idea of trends, such as a change over time.

Each line in the body of the graph represents a different set of data and the identity of each line must be made clear to the reader (e.g. one dashed, one dotted or use triangles, squares, etc as symbols on your line). Keys to the graphs will be placed within the area of the graph, usually in the upper right-hand corner. For some lines, it is more appropriate to connect the dots, and for some you would want to create a best-fit line. This choice depends on your data, so each case will be different. Ask your instructor for directions on a specific data set.

Tables

The caption (title) is placed at the top of the table. Start with the word "TABLE" written in all caps and left aligned. This format will be followed with the appropriate table number, then a period. A description of the table follows with only the first letter of the first word capitalized. Additional sentences may be needed and will be left aligned as well.

Every column has a **heading (including units)** indicating what the numbers in the column mean. Only the first letter of the first word in the heading is capitalized. The data will be arranged in the table so that like elements read down (all time measurements, all weights, all seed lengths, etc...).

Vertical lines or horizontal lines are usually not used in the table. Horizontal lines will be used to separate the title from the column headings, the headings from the subheadings, the subheadings (or headings) from the data. A line is also included at the bottom of the table to separate the data from the narrative text. The table needs to be completely self-explanatory. A test of a good table is to give it to someone who has not done the experiment or read the rest of your paper and ask them if it is clear and complete.

DISCUSSION

This section is where you discuss the relationships, interpret data, and draw a conclusion based on your original hypothesis. **You must make explicit whether your data supports your original hypothesis, or whether you reject your original hypothesis.**

Summarize your data, but refrain from reporting specifics about your data in this section. That part will have already been done in the Results section. When drawing your conclusion,

keep in mind any details or possible mistakes that may have altered your results. If they are significant, mention them here. **If you think you did the experiment incorrectly**, discuss your error at this time. Don't list all possible errors, just the one obvious error and only mention it if you are sure that it significantly influenced the outcome of your experiments. **If you think that overall you did the experiment correctly**, but came up with unexpected results, discuss this as a new discovery and don't doubt your results or write conclusions in a self-doubting tone. (It is possible that you were supposed to get those unexpected results!). **Do not conclude that you have "proven" anything.** It is EXTREMELY difficult to prove anything, and one experiment is virtually never enough to make this sort of statement. Instead, state your results and possible explanations. This section is also where you suggest any future work and emphasize the importance and usefulness of your findings and experiments of this type. What do your results *mean*? This section of a scientific paper is arguably the most critical, most difficult, and most important section of your paper. Many scientists compose this section last. It often is one of the more lengthy sections of the paper.

LITERATURE CITED

You must acknowledge the source of ALL material that is not your own. A thorough paper contains literature citations of published studies within the text. For example:

1. The most recent study of antagonistic behavior in this species (Newman 1989) suggests...
2. In Tyler's (1990) model of predator-prey relationships...

The literature cited section includes *all* the literature you have cited, but it is **not** a bibliography. **List only citations that have been mentioned in the text.**

1. Example for a book:
Williams, T.K. and B. Perkins. 1999. Genes, Genotypes, and Genomes (4th ed). Academy Press, Tokyo. 789 pp.
(*Authors, Year, Book, Edition, Publisher, Location, Pages*)
2. Example for a research paper:
Public, J.Q. 2002. The meaning of life. *Jamaican J. Polar Res.* 8:10-3456.
(*Author, Year, Title, Journal, Volume, Pages*)

GUIDELINES FOR REFERENCES

- Internet references from government sources (*e.g.* National Science Foundation, United States Dept. of Agriculture...), **reputable** organizations (*e.g.* Amer. Assoc. Advancement of Science, United Nations...), and **large** companies or corporations (Cable News Network, British Broadcasting Corporation, Proctor & Gamble...) are acceptable **ONLY** if your citation is **complete** (who, what, when, where...).

- Do NOT simply cite a web address. Think about it – A single typo renders it useless.
- It's OK to mention when you looked at an internet source, but it doesn't provide the reader with anything other than a *guess* that it *may* or may not be in existence anymore if someone is reading *your* paper *in the future*. DO, however, include the date **OF** the article or website.
- Do not use acronyms in your references unless they occur in the exact title of an article.
- Non-reviewed websites (*e.g.* from individuals, small businesses...) are not reviewed/credible and thus should **never** be used as any type of authority. Remember, *anybody* can say *anything* on a website. Do NOT reference Wikipedia.
- Do not lift a citation from within a website or article unless you, yourself, have read that citation. Think about it - You may be perpetuating a typo, a mistake or, worse, a lie. Remember, *anybody* can say *anything* on a website.
- Every one of your citations in your paper must be included in your References section, and all of your sources listed in your References must be cited at least once within the body of your paper. There is no point to include a citation in you References list if you didn't use it. Similarly, there is no point of having a citation in your paper with no information on how to find it.
- If you borrow someone's idea, concept, description, information, etc., but changed the wording, you **MUST** cite them. Use (author, year) format within your paper. If you borrow someone's words exactly, you must use quotation marks. If you've only changed the wording very slightly, say, a single word in a sentence or a few words in a paragraph, then stop beating around the bush – use it verbatim with quotation marks.
- Your References section **MUST** include ALL possible information to assist someone in obtaining that reference, such as:

Author(s)/Institution
 Year published
 Title of article
 Source (journal, Name of website...)
 Volume, Pages

Here is one reason why internet sources can be a problem. You likely will have to surf all over a site's individual pages to find the pertinent information. Oh well – do it. If you're having trouble finding this type of essential information then ask yourself this question: "Do I really trust this information if there is no name, date, and/or institution clearly associated with it?"

GENERAL CONVENTIONS FOR YOUR ENTIRE REPORT:

- Spell numbers at the beginning of sentences, but not elsewhere.
- More than one or two significant digits (beyond the decimal point) is *rarely* justified.
- Begin numbers less than one with a zero (*e.g.* 0.7, not .7).
- Do not start each section on a new page; however, do place section headings on a new page if the page break comes directly after the section heading.
- *Escherichia coli* (or any species name) should be underlined or italicized. You may abbreviate it to *E. coli* after the first time it is used, but only if it cannot be confused with any other organism mentioned in your study.
- Include actual amounts and times you used, not a range.
- Use passive voice (The enzyme *was added*, not *We added* the enzyme).
- Use past tense (The enzyme *was added*, not *Add* the enzyme).
- If you begin a sentence with the word *This* or *That*, ask yourself “This or That *what?*” Your sentence *MUST* have a subject! This *error* is very common.
- Do not use personal pronouns or possessives (*e.g.* we, she, I, our, his...).
- 12 point font maximum, text double spaced.
- 1.0 inch margins *maximum* (top, bottom, left, and right).
- Type *everything* (except the graphics portion of complicated figures).
- Indicate time in days, not dates.
- Do not cite a citation within a paper unless you yourself have read that original paper.
- All of your citations must be included in your References section, and all of your References must have at least one citation to each of them within your paper. Check them *both* ways.
- Typographical errors are a sure-fire reason for your reader(s) to question the accuracy of your research.

Your report must be **typed** and no more than four or five pages of text (exclusive of figures or tables). Your writing style must be clear, concise, and grammatical. While it is true that this is not an English composition course, any paper is worthless if the reader cannot understand what the author is saying. No experiment, however brilliant, can contribute to the existing fund of scientific knowledge unless it has been **clearly and accurately described**. Also, in the scientific community (as well as elsewhere), the merit of the work will be judged at least partially on how it is presented. Typographical errors, misspelled words, missing periods, irregular spacing, and other minor errors distract the reader and undermine your authority as a writer *and* as a scientific investigator. For example, there is a tendency not to trust data if they are surrounded by careless misspellings. The aim of proofreading is to eliminate such mistakes, so that you can present a persuasive final manuscript.

If you follow all of these guidelines, you should receive an excellent grade for your report. Conversely, if you do not follow these guidelines, you will receive a poor grade for your report, **or it may be returned without any credit given**. Therefore, it is strongly recommended that you read through these guidelines *both before and after* you write your report, to ensure that the correct format is used.