Part 1: Lab Reports

Some of your science classes at Millersville University will require you to complete lab reports or term papers for simple experiments to show that you understand the scientific method. The scientific method usually includes (1) an Introduction section, (2) a Materials and Methods section, (3) a Results section, (4) a Discussion section and a Literature Cited section.

The goal of a lab report should be to simply present the facts. The goal of science is truth, thus no persuasion is necessary in this type of document.

Overall writing formats or guidelines for these lab reports should include the following:

1. The reports should be typed and double-spaced using a computer. Reports should be in 12 point size, Times New Roman style, have 1 inch margins, and organized neatly for the reader to understand your experiment.

2. Correct spelling and grammar is a must, and the report should be written in complete sentences (with subject and verb). Points may be deducted for incorrect spelling and grammar.

3. Past tense should be used whenever writing about what you did in lab, since what you did happened in the past.

5. Each section should be labeled with the appropriate heading (Introduction, Materials and Methods, Results, Discussion, Literature Cited).

6. Do not plagiarize (the "wrongful appropriation" and "stealing and publication" of another author's "language, thoughts, ideas, or expressions" and the representation of them as one's own original work).

7. To help with clarity: proof-read, then have somebody else proof-read, and then proof-read again.

The Following page begins an example lab write-up. Comments throughout this example outline the reasoning for the writing style and further details on how to follow a proper scientific writing style. THIS EXAMPLE IS TEXT LIGHT FOR YOUR BENEFIT. YOUR PAPER WILL HAVE MORE SOURCES AND WAY MORE TEXT FOR EACH SECTION.

John Smith
Principles of Zoology/Section B
Lab Report #3

Comment [ah1]: Student name, class, lab #, and date should be at upper left and single-spaced.

IMPACTS OF NITROGEN ON PLANT GROWTH

JOHN SMITH, Millersville University, Millersville, PA, 17551.

Comment [AH2]: Student name and school address.

Abstract: We wanted to evaluate the effect of nitrogen fertilizer on American water weed (*Elodea Canadensis*) biomass growth. Our hypothesis was that more nitrogen fertilizer would increase plant biomass. We used 5 cultured bowls in which to grow plants. Each cultured bowl contained an increasing amount of nitrogen fertilizer, starting with bowl 1 with the least amount with increasing to bowl 5. We conducted 2 separate experiments to evaluate consistency of results. We found that plant biomass growth increased with more nitrogen fertilizer to a point. At the highest levels of nitrogen, plant growth declined dramatically. Both experiments had the same conclusion with results having no significant difference ($P > 0.05$). We suggest further research into the potential toxic impacts of too much nitrogen fertilizer on plant growth.

Comment [AH3]: Term paper or lab reports should include an abstract page after the title page. An abstract is a paragraph that summarizes the whole paper (all sections). I would recommend writing the full paper and then writing the abstract last. This will make things easier.

Developing a complete and solid abstract is very important. Many times you will be submitting this abstract of your research to scientific symposiums and conferences so that you can gain approval to present your research at these venues.

Comment [AH4]: Your abstract only needs to be one paragraph. It should include the goals of the paper, main points you found, results and any discussion of these main points to your hypothesis, future research needs or final conclusions.

Citations are not in the abstract.

Introduction

The purpose of this lab was to examine the effect of nitrogen fertilization on plant growth. Nitrogen occurs in all living organisms and is believed to be an important nutrient for plant growth (Chalk 1991). To evaluate the impacts of nitrogen on plant growth, the aquatic plant American water weed (*Elodea canadensis*) was grown in water containing different amounts of nitrogen. Ammonium nitrate was used as our source of nitrogen fertilizer.

The hypothesis tested was that since American water weed requires nitrogen to make organic compounds like proteins (Chalk 1991), the more nitrogen it has available, the better it should grow. The null hypothesis was that nitrogen would have no impact on plant growth.

Comment [ah5]: In the Introduction you start out describing a question about what your research is going to answer. Then you give background literature on all the other studies that have tried to answer this question or tried to answer questions similar to the one you are doing research on. Then you briefly state the objectives of your experiments and the type of experiments you performed. Towards the end of your Introduction you specify the goal of your experiments and state a hypothesis of what you expect to happen during the experiment.

Your introduction will be much longer.

Comment [AH6]: Citation style from source that had 1 author.

Comment [ah7]: For every organism mentioned you should include its scientific name when it is first mentioned. This includes the genus name that is capitalized and the species name in lower case. The scientific name is in italics and in parenthesis.

Comment [ah8]: Lab is written in past tense. This lab is on work that you have already completed.

Materials and Methods

Five glass cultures bowls were filled with one liter of distilled water. Each bowl was given a different amount of ammonium nitrate as displayed in Table 1.

Table 1. Grams of ammonium nitrate added to each culture bowl to evaluate the impacts of nitrate on plant growth.

Bowl no.	Ammonium nitrate (g)
1	0 g (negative control)
2	0.1 g
3	1 g
4	10 g
5	100 g

Five sprigs of American water weed, with a mass of about 0.4 g, was placed into each culture bowl. The culture bowls were placed in a growth chamber set to a12 hr light period per day and an average temperature of 28 °C for three weeks. Water was added during the course of the experiment to keep the solution level at one liter in each bowl, but no additional ammonium nitrate was added. At the end of the three-week period, the mean final mass of each American water weed plant from each culture bowl was recorded and then compared for analysis. This same procedure was run again for 5 more bowls to test for experiment consistency.

We used a student t-test assuming equal variance to compare the means between the 2 experiments using the EXCEL program. Statistical significance was based on a p-value ≥ 0.05.

Comment [ah9]: Provide a discussion, in your words, of the procedures you performed and all the materials you used during the course of your experiments. The Materials and Methods section should be written with clarity so another individual could successfully replicate this experiment based on your description. This section is written as a narrative, NOT a bullet list of things you did.

Your Methods and Material will be much longer.

Comment [ah10]: Again the use of past tense.

Comment [ah11]: All tables need to be referenced in the text before they appear in the report.

Comment [ah12]: Every table should be labeled and numbered based on when it is referenced in the text. The data in this table was referenced first, thus this is Table 1.

Comment [ah13]: Each Table should have a caption consisting of a sentence or two describing the data in the Table. The goal of producing a table is to be able to have it stand alone so someone could read the table without reading the text and still understand the data being recorded. Captions for Tables are located on top of the table. Data in the table is centered, except for the first column which provides labels for each row. Tables should not have vertical lines, thus DO NOT cut and paste from EXCEL.

Comment [ah14]: No vertical lines should be in the tables. Vertical lines make the data harder to see and make the table look incomplete. All data should be centered except for the first column.

Comment [ah15]: All numbers need to be written out when beginning a sentence.

Comment [AH16]: Note that this sample size is too small. Again, this is a shortened lab report for guidance purposes.

Comment [AH17]: All numbers should have a digit in front of a decimal if there is a decimal.

Comment [AH18]: Make sure all your numbers have the correct units indicated.

Comment [AH19]: The end of the materials and methods section should describe the quantitative analysis that was conducted. This is what statistical test you used to analyze data.

Results

We wanted to test to see if the amount of nitrogen fertilizer impacts plant biomass growth. Plants with higher levels of nitrogen had greater plant mass except for bowl number 5 (Figure 1). We found the same results for both experiments, where the mean of experiment 1 was 2.23 and mean of experiment was 2.10 (Figure 2). The t-statistic value was 0.25 and was less than the t-critical value of 2.31, also the p-value was 0.81 which is greater than 0.05 (Table 2), thus we found no significant difference in plant mass between experiments 1 and 2. The American water weed plant in bowl 5 had started to turn brown and looked like it was dying, but the plants in all other bowls looked green and healthy.

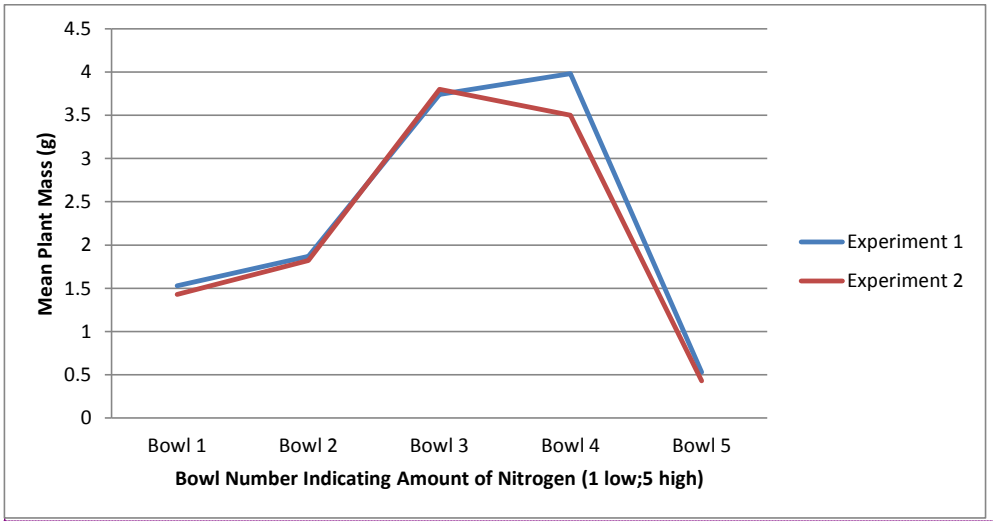

Figure 1. Mean plant mass in bowls of increasing amounts of nitrogen for 2 experiments. Bowl one had low levels of nitrogen while bowl 5 had very high levels as outlined in Table 1.

Comment [ah20]: Your results should have text which directly and concisely tells you the results of the experiment. The results of your experiments can often be displayed in the form of tables or figures (graphs or pictures). It is customary to number and label each table and figure, and then refer to each table and figure, in order, in the text of your report.

Your results section will be longer.

Comment [ah21]: All paragraphs should be more than one sentence.

Comment [ah22]: All axis should be labeled and have correct units.

Comment [ah23]: All Figures should have a caption which is located at the bottom of the figure (this is different from the Tables which have the caption up top). Like Tables, every Figure should be referenced in the text and then displayed after referenced. Figures should be labeled in the order they were referenced and should be able to stand alone for interpretation.

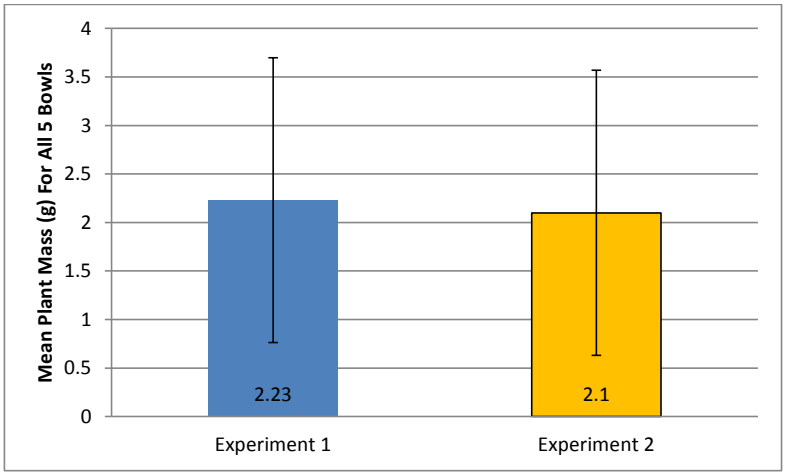

Figure 2. Mean plant mass and standard deviation error bars for all 5 bowls in experiment 1 and 2. Comparative statistics are outlined in Table 3.

Comment [ah24]: All Figures should have a caption which is located at the bottom of the figure (this is different from the Tables which have the caption up top). Like Tables, every Figure should be referenced in the text and then displayed after referenced. Figures should be labeled in the order they were referenced and should be able to stand alone for interpretation.

Table 2. Results of a student t-test assuming equal variances between 2 experiments that both tested impacts of nitrogen levels on plant biomass growth. There was no significant difference between the two experiments (t-statistic t< t-critical; p-value = 0.81).

	Experiment 1	Experiment 2
Mean	2.23 g	2.10 g
Variance	2.20 g	1.79 g
t-statistic	0.25	
t-critical	2.31	
2-tailed p-value	0.81	

Discussion

The results of the experiment generally matched what was expected based on the hypothesis being tested, with the exception of the bowl 5 results. It was thought that increases in nitrogen would lead to increases in plant growth. Plant mass did increase with increasing nitrogen in bowls 1 through 4, but declined in bowl 5 (Figure 1).

The plant in bowl 5 showed the least growth. It only had one-third of the mass when compared with the negative control (i.e., bowl 1). Even though it was given the most nitrogen, the plant in bowl 5 appeared to be dying. There could be various reasons for this result. It is possible that the plant had developed a disease during the experiment (Campell and Madden 1990), but this would have to be investigated more. Another possibility is that the nitrogen level in bowl 5 was too high, and was toxic to plant growth at that level. Britto et al. (2001) found that high levels of ammonium (a nitrogen source) can have toxic implications for a number of plant species. Repeating the experiment may help determine which of these possibilities is correct, and if high levels of nitrogen can be toxic to plants.

Comment [ah25]: Mention the conclusions you have drawn from the data you have presented in the Results section. Defend your conclusions by referring to the supporting data. Indicate whether your results agree or disagree with your hypothesis, and attempt to explain possible reasons why your results may not fit your hypothesis. Compare your results to those of other research in peer-reviewed literature to help explain your results.

Your Discussion will be much longer.

Comment [AH26]: Citation style for a source with two authors.

Comment [AH27]: Citation style for a source with more than two authors.

Comment [ah28]: Your discussion should also have text on why your hypothesis was supported or not supported.

Comment [ah29]: Always good to give recommendations of what the next step should be after your experiment has been completed.

Literature Cited

Britto, D. T., Siddiqi, M. Y., Glass, A. D., & Kronzucker, H. J. 2001. Futile transmembrane NH4+ cycling: a cellular hypothesis to explain ammonium toxicity in plants. Proceedings of the National Academy of Sciences 98: 4255-4258.

Campell, C. L. and Madden, L.V. 1990. Introduction to plant disease epidemiology. John Wiley & Sons. New York, New York.

Chalk, P.M. 1991. The contribution of associative and symbiotic nitrogen fixation to the nitrogen nutrition of non-legumes. Plant Soil 132: 29–39.

Comment [AH30]: Should be in alphabetical order and list all the citations used in your paper. All citations used in the text should be listed here.

Make sure your literature cited section is in the proper style for journal articles, books, book chapters etc. Do not use webpages. Come see me if you need to use one as a source. Follow the style guidelines outlined in your lab manual.

Your Literature Cited will be much longer.

Comment [AH31]: Make sure you are using the original sources for your information. If a book or journal article cites another source for the information you use, you must cite the original source.

COMMON WRITING ERRORS

Written and oral communications are extremely powerful ways of representing yourself to others. Using proper grammar when speaking and writing for professional audiences can be a tremendous asset to your professional success. Obviously, inadequate writing or speaking will severely limit your career development.

☞ *Attention to detail and **proofreading** your work will be critical to successful writing!*

ERROR	TYPE OF ERROR	COMMENTS
1	Incomplete sentences	Topping the list of writing errors is incomplete sentences. Incorrect: The two extractions were combined. Then dried for five hours. Correct: The two extractions were combined. They were then dried for five hours.
2	Subject-verb agreement	If the subject is singular (or plural) the verb must match appropriately. In the following defective sentence, the noun is plural while its verb is singular. Incorrect: Our results indicates the significance of intracellular signaling systems. Correct: Our results indicate the significance of intracellular signaling systems.
3	Misspelled words	Use your spell checker! Remember, the only way to really check spelling is to **PROOFREAD** your work because spell checkers do not catch all errors.
4	Affect vs. effect	"Affect" is a verb, "effect" is a noun. Remembering the acronym "NEVA" (noun effect verb affect) may help. Examples: The effect of the medication was noticeable. Medication rates affect the level of hypertension.
5	Data vs. datum	"Data" is plural, "datum" is singular. Examples: The data are .... The datum is...
6	Do NOT use quotes	Avoid using verbatim quotations from technical references. Instead, reword phrases/ideas from the reference and then cite the reference that presented that idea. Example: “To be or not to be, that is the question”. Revision: The ultimate question is whether or not one should pursue existence in this life (Shakespeare, 1592).
7	Use of contractions (especially its vs. it's)	"It's" is the contraction of "it is". In general, avoid using any contractions in scientific writing. Incorrect: Results didn't differ among treatment groups. Correct: Results did not differ among treatment groups.
8	Writing numbers less than 1.0	(.78 vs. 0.78) When writing a number that is less than 1.0, always place a zero to the left of the decimal. Incorrect: .454, .8, etc. Correct: 0.454, 0.8, etc.

9	Writing numbers (general rules - these rules vary somewhat in different style manuals)	Spell out numbers at the start of a sentence and one digit numbers (zero – nine) appearing anywhere in a sentence. Never begin a sentence with a numeral. Use numerals when a number has a unit of measure, when reporting statistics or when the number refers to a page, time, date, figure, table, magnification, etc. In a series containing some numbers greater than nine, use numerals for all. Note the appropriate use of numbers in the following examples: Fifteen chickens crossed the road. (incorrect: 15 chickens crossed the road.) Insects have six walking legs. We had 425 insect specimens in our collection. All 10 of us attended lab this week. Ten of us attended lab this week. Most tissue samples weighed less than 15 grams. Several tissue samples weighed less than 4 grams. The audience included three students and eight instructors. The audience included 3 students, 8 instructors, and 13 chinchillas. The experimental diet caused body mass to increase by 5% (Table 2).
10	Writing species names	Biologists are especially 'picky' about writing species names. See lab manual pg. 42 for important rules that apply to zoological nomenclature. Incorrect: homo sapiens, Homo sapiens, Homo Sapiens, Homo Sapiens, etc. Correct: *Homo sapiens* (or Homo sapiens when handwritten)
11	Since vs. Because	"Since" should be restricted to making time comparisons. Incorrect: Since they have rich soil, tall-grass prairies were rapidly converted to row crop agriculture. Correct: Since settlement by Europeans, tall-grass prairies have largely disappeared. Because of its rich soil, tall-grass prairies were rapidly converted to row crop agriculture.
12	When to use "*et al*."	The phrase "*et al.*" is used when making an internal citation of a work that has three or more authors. (Review internal citation format, pg. 24 in your lab manual.) Because this phrase is derived from Latin, it is usually italicized. Examples: Smith *et al.* (1983) found that... (indicates that this reference had at least three authors, the first of whom was Smith). Smith and Jones (1999) found that... (indicates that this reference had two authors).
13	Than vs. Then	The word "then" is used in many ways, but it is always used to denote time or sequence in some way, shape or form. The word "than" is a conjunction used in comparisons. To put it simply, if you are doing a comparison, use "than"; if not, use "then."
14	There vs. Their vs. They're	The word "there" indicates location. The word "their" is the possessive for "they." The word "they're" is a contraction for "they are."