Campus Academic Resource Program

Writing a Science Lab Report

This handout will:

- Describe a lab report and its necessary components.
- Elaborate on the organizational structure of the Introduction and Conclusion sections using the "Hourglass" structure.
- Give examples of how to write a hypothesis using the "If/Then" statement formula.
- Outline the necessary components of the Methods and Materials section.
- Discuss elements of the Results and Discussion sections as well as outline how to write figure captions.
- Review the importance of including references and citations, and outline the necessary components within the Reference section.

I. Components of a Lab Report or Research Paper

Overview

A lab report's primary function is to provide a detailed overview of the experiment that the experimenter performed. The lab report, however, should never read as an instruction manual; rather it should contain enough detail that another scientist can replicate the procedure with minimal confusion. The report should also give enough background information on the topic discussed to contextualize the experiment with other research on similar topics.

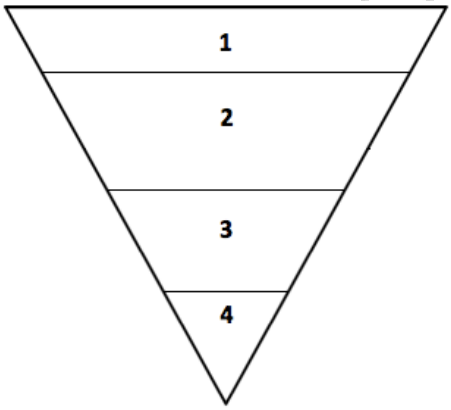
A lab report should include a title at the top and is typically organized into six sections: *Introduction, Materials and Methods, Results, Discussion, Conclusion, and References.* Some professors may also ask you to include an abstract. For more information see "Writing a Science Abstract" handout at http://carp.sfsu.edu/content/helpful-handouts.

II. General Structure and Purpose of Each Section

Introduction

The Introduction should serve as a "lead-in" to the experiment you conducted; it explains any background context—such as terms used in the experiment the reader may not be familiar with—and the rationale behind the experiment. It should ultimately allow your reader to understand research questions that the experiment answers, why these questions are important, and what other research has been done to broaden the scope of knowledge regarding that particular topic. When writing your Introduction, it may be helpful to consider the "hourglass" organizational structure, depicted below.

Using this structure, the Introduction should begin with broad information, giving the "big picture" of the topic's importance and relevance first before gradually discussing more specific information about the experiment. Eventually it will state the particular research questions of the experiment.



1. Briefly describe the broad subject, beginning with generalized information. This should include any general scientific terminology used during the experiment and concepts that the reader may not be familiar with.

2. Elaborate on details specific to the experiment. Discuss previous work on the subject (or lack of previous research), and other information about relevant processes, organisms, or locations that are needed to understand the context of the report. This would include any interesting molecules used or made during the experiment—this can also be referred to as the reaction scheme and mechanism.

3. The Introduction should also briefly explain the particular methods utilized in the investigation, and why they were specifically chosen over other methods.

4. The hypothesis or research question should be clearly stated in the last few lines of the Introduction. However, do not discuss any results or conclusions, as you will discuss it explicitly later on in the Conclusion of the lab report.

Hypothesis

Hypotheses are a significant part of any lab report; they act as the paper's thesis statement and provide structure for the entirety of the paper afterwards. A true hypothesis will be testable (can be experimented on), falsifiable (can be supported or disproved based on evidence collected), and will discuss the independent and dependent variables used within the experiment. Simpler labs may have shorter hypotheses, while more complex labs may require multi-sentence hypotheses to properly cover all the content in a lab. The hypotheses should be formulated before the experiment or in accordance with it, according to the predictions you have previously made. Your hypothesis should be formulated based on predictions you make before or during the duration of your experiment.

A common type of hypothesis used in many basic lab reports is an **If/Then statement**. These hypotheses dictate cause and effect scenarios ("If in the event that X occurs, then Y will happen as a result of it"). In this case, the "If" portion of the statement describes the **independent variable(s),** and the "Then" portion describes the **dependent variable.**

Some examples of If/Then statements include:

- *If* the temperature of the agar solution is increased, *then* the number of bacterial colonies grown will increase.
- *If* CO_2 input increases in concentration, *then* stomata size will proportionally increase as well.
- *If* surface area of a rectangular object is increased, *then* air resistance will increase and the falling rate of the object will slow.

Exercise #1

Directions: Use the information provided to write your own hypotheses, using the "If/Then" statement structure.

1.) Make a hypothesis about the relationship between types of fertilizer used and plant growth, by measuring the heights of the plants after 2 weeks.

_____
_____
_____

2.) Make a hypothesis testing if higher temperatures affects the rate at which sugar dissolves in water by measuring the amount of sugar in grams at different temperatures.

_____
_____
_____

3.) Make a hypothesis testing if a higher voltage of electricity affects the speed at which an electric motor runs, by measuring the amount of rotations per minute at different voltage intervals.

_____
_____
_____

Methods

The Methods (often called the "Materials and Methods" or "Experimental") section outlines the steps completed throughout the experiment. Your materials, generally, do not need to be listed separately as you will describe the materials and their uses multiple times throughout the lab report. This section should be detailed enough that another knowledgeable scientist in the field could be reasonably expected to replicate your procedure. However, it should not read as a list of instructions. Common procedures (such as titration or a gel electrophoresis) are generally named (*i.e. a protein array was completed for X sample*) rather than described step-by-step. The methods section should be written in past tense, since it describes actions that have already been completed. Most methods sections are also written in passive voice, unless a professor requests otherwise. For more information see "Active and Passive Voice" handout at http://carp.sfsu.edu/content/helpful-handouts.

The following format can be used to write a Methods Section:

1. Introduce, in one or two sentences, the procedures used and the type of data collected.
2. Explain the steps of the experiment chronologically (i.e. explain them in the order that the steps occurred in).

   Ex. "The first treatment was black paint with a clear finish to control for the smell of the paints; a clear finish was used to prevent the altering of the original pattern. The second treatment used a clear finish on the

dorsum to reduce any scent emitted or otherwise affect the female's behavior. The third treatment was black paint on the dorsum to mimic the color of the fifth instars.

3. Note any deviations (outliers) or unexpected circumstances (such as confounding variables) that affected your intended procedure.
   Ex. "Though most flies followed the general pattern of being attracted to female flies painted with a black coat, two or three of the test subjects exhibited strange behavior in that they ignored the female flies with black coating and preferred the female fly with a striped orange and black pattern. The orange paint was changed to a non-scented brand in a similar color during the second round of observations."
4. Describe the methods you used when analyzing data (such as statistical tests or analysis software).
   Ex. "Some tests that the researchers used to analyze the data were statistical tests, such as the Confidence Interval Test, to find differences between the males mounting times during the trials for each of the three treatments and the three other control trials."

Depending on the length and complexity of the report, it is acceptable to break up the Methods section into subsections. This should be done in the event that you need to describe, in detail, specific procedures or tools, study populations, and/or analysis methods.

Exercise #2

Directions: Rewrite this Methods section from first-person active voice to third-person passive voice.

Today in the lab, I observed the rate of photosynthesis in plants. First, I took the leaves and punctured along the stomata using a hole-puncher. After that, I removed the little circular pieces and put them aside for later use in the experiment. Then I filled a clear beaker with water and placed it under a desk lamp. I placed the section of the leaves that were hole-punched in the beaker and timed how long it took for them to begin to sink. I waited for 2-3 minutes and observed the oxygen bubbles forming around the little circular pieces, and stopped the timer when they sank past half an inch.

Results

The Results section often contains the least amount of text. The purpose of the Results section is to present the most important data or major data trends both clearly and concisely. The Results section should also include any mathematical calculations and their results, as well as any measurements recorded during the experiment (i.e. the melting point or mass). Although it is important to note significant points in data, analyzing trends and outliers in data should be addressed later in the Discussion section.

Tables and Figures

Another common way to present the data/results concisely and clearly is through graphs and table forms. Both graphs and table forms should include short descriptive captions. While captions for a *table* must be formatted *above* the table, captions for a *graph* or other figure should be *below* the graph. Ask your professor how they would like you to integrate visuals, as it will vary according to the citation style used. For more information see "Integrating Visuals" handout at http://carp.sfsu.edu/content/helpful-handouts.

Writing Effective Captions

Captions provide key information for the reader concerning the data collected in the experiment, and a brief caption is absolutely necessary for every table and figure included in the results section. An effective caption will provide enough information about the data so that a figure or table can be completely separated from the rest of the report and still convey the same, basic idea. A caption will include a sentence or phrase describing what data is included within the figure/table, how the data was collected (in around one sentence), and some information about the units/analysis of the data.

Notice that since the following example is a *table,* the caption is placed *above*.

Table 1: Key location and species identification data for surveyed transect points, including species, elevation (as determined by level survey) and distance from P0. Data was collected using a point-intersect method and a randomly generated number chart.

Point ID (#)	Species	Elevation (msl)	Distance (m)
P17	Lupin	11.2	12.53
P18	Sagewort	15.3	13.43
P19	Beach Strawberry	19.4	17.05
P20	Sagewort	14.7	19.81
P21	Beach Bur Brush	18.2	22.57

Notice that in this example, the caption is placed *below* the *graph*.

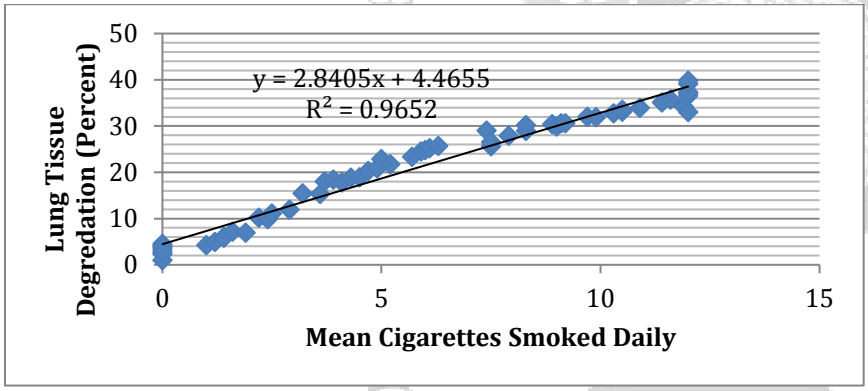


Figure 1: Percentage of lung tissue degradation of the 58 test subjects as a function of average number of cigarettes subjects smoked daily. Mean cigarettes smoked daily ranged from 0 to 12. The R value for the data set is .9652.

One or two paragraphs recognizing major data trends should accompany these tables and figures, and be incorporated into the larger topic discussed in this lab report. However, your analysis and interpretation of data should not be included in the Results section. Your explanation of what the data "means" should be confined to the Discussion and Conclusion sections immediately following the Results. While the Conclusion section can include your personal analysis and some degree of subjectivity, the Results section is meant to be as objective as possible, displaying and describing the data collected as they were originally conceived.

Discussion

The Discussion section is where you interpret the results of the experiment and relate the results back to the hypothesis, stating whether or not the data supports it. The Discussion section is also where you explore the trends that you discovered in the Results section, and elaborate on their relation to the larger topic being experimented on. In this section, you should mention the results you expected to see and whether or not you observed them in your experiment—elaborate on the possible reasons as to why you may or may not have seen them. You will also discuss unexpected results you encountered in your experiment and possible causes of these results.

When writing a discussion section, ask yourself probing questions about the experiment you conducted in order to think broadly, actively, and critically about your experiment. Below are examples of thought-probing questions to ask yourself about the experiment:

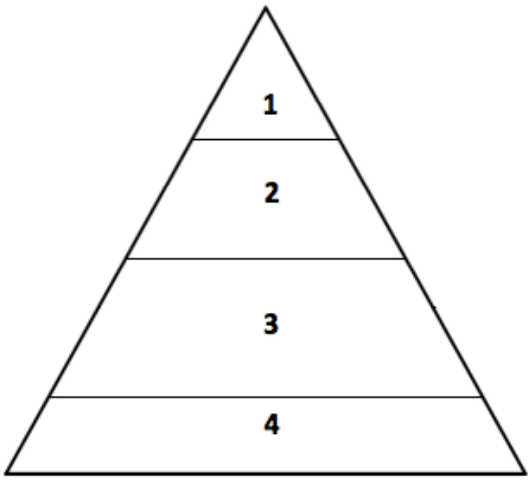
- "Was the equipment used adequate for the task?"
- "Was the experiment design valid? If not, what aspects of your experimental design could have caused discrepancies in your results?"

- "Were the working assumptions made correctly? In other words, were the results you conceived highly probable and scientifically based or made based on theoretical assumptions?"

Never be afraid to elaborate on the reasons you might have encountered these particular results. This section is where you discuss the results of each trial in detail, explaining noticeable patterns and significant differences while also addressing similarities across the trials. This section should also include suggestions for future experiments that can be conducted to gain further knowledge on the topic as a whole.

Conclusion

The purpose of the Conclusion section is to contextualize the information gathered from the experiment. In other words, it is your responsibility as the author of a lab report to take the ideas garnered from your data in the Results and Discussion section and make it transferrable/applicable to the real world. As in the Introduction section, it can be helpful to organize your using the "hourglass" format, shown below. Though this format mirrors the one presented in the Introduction, it is inverted so that it *starts* specifically, addressing your data and findings, before gradually broadening the scope to discuss the overall significance of your experiment.



1: In this section, important results from the experiment are restated and their significance should be explained.
Ex. "Beach Strawberry and Beach Bur Brush were found at 19.4 and 18.2 meters, respectively. This is significant because—"

2: This section should also include a discussion regarding the validity or accuracy of the results made while accounting for error or other extenuating circumstances that occurred during the experiment. It must also be determined if the hypothesis is supported, disproved or proven null by the results. If results differed greatly from expectations, the data's abnormality is usually connected to the potential sources of error.
Ex. "Beach Strawberry and Beach Bur Brush were the only plants found above 17 meters, supporting our hypothesis that habitat of the Beach Brush Sparrow is limited to areas above this elevation."

3: Once you reach your conclusions, relate them to other research being done in that area. Did other researchers have similar or significantly different results? Could differences/similarities in methodologies account for this? Do the results of the lab relate to any cutting edge research being

done on the topic, or could research in other fields/topics be integrated into this field to provide new insight?
Ex. "While previous studies have found Dune Brush at lower elevations, the Beach Bur Brush and Strawberry Brush are critical food plants for the Beach Brush Sparrow, and our findings reflect that these habitats are even more critical than previously thought."

4: The final part of the discussion answers the question, "Why does this study matter?" An easy way to answer this question is by providing/ suggesting new avenues of research based on the research's findings or describing the practical applications of the results from the study.
Ex. "Our findings have important applications in the habitat management of this endangered bird species."

Generally, the bulk of the Conclusion section is comprised of two sections (numbers 2 and 3 stated above). Reiteration of Results should be limited to what is necessary to remind the reader of your findings. As you address the meaning of the data, briefly describe future research that relates to your experiment and its greater significance. Each of these sections (1 and 4) usually only require a few sentences each.

Exercise #3
Directions: Write a practice conclusion, using the "hourglass" template, and the data provided below. Be sure to include all the aspects of a conclusion described above.

DATA

Data Obtained: 2/25/95, Mankato, MN	
Amount of boiling water	2 Cups
Temperature of boiling water **(Control)**	212.9°F
Amount of table salt added to boiling water: Run #1	1 Tbl.
Temperature of boiling water after adding salt: Run #1	215.6°F
Additional amount of table salt added to boiling water: Run #2	1 Tbl.
Temperature of boiling water after adding salt: Run #2	218.3°F

EXPERIMENTAL OBSERVATIONS

When the salt was added to boiling water it bubbled up more, and then stopped boiling. Shortly afterwards, it boiled again.

If the thermometer extends beyond the outside of the rim of the pot, it reads a higher temperature. Heat from the stove burner makes the thermometer read higher. Keep the thermometer over the pot when making temperature measurements in future experiments.

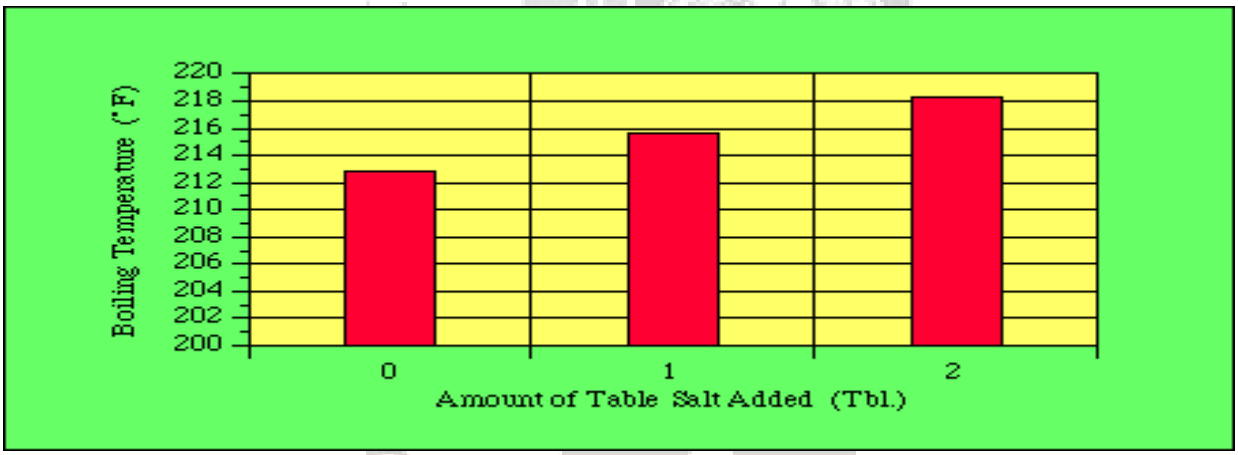
CALCULATIONS

- Total amount of table salt added for Run #1: 0 + 1 = 1 Tbl.
- Total amount of table salt added for Run #2: 1 + 1 = 2 Tbl.

RESULTS

Temperature of boiling water **(Control)**	212.9°F
Amount of table salt added to boiling water: Run #1	1 Tbl.
Temperature of boiling water after adding salt: Run #1	215.6°F
Total amount of table salt added to boiling water: Run #2	2 Tbl.
Temperature of boiling water after adding salt: Run #2	218.3°F

Amount of Table Salt Added Versus
Water Boiling Temperature



Conclusion:

References

A reference page is a list of all citations included throughout the report, with pertinent author and publication information included. A reference sheet only includes sources cited within the paper, not suggested reading or related articles.

The reference page provides your audience with the means to verify your sources and determine where you based your experiment and analysis on. Most importantly, if your readers are interested in any of the information presented in your report, they can read even more extensively about the topic and potentially incorporate this into their own work. It is crucial to include all your resources to protect you, the writer, from accusations of plagiarism (assuming that all sources have been utilized and cited correctly). Most college-level lab reports, especially in the biological sciences, use APA style. For more information see "Guide to American Psychological Association (APA) Style" handout at http://carp.sfsu.edu/content/helpful-handouts.

Refer to your professor regarding which style they would like you to cite with on your lab report, and remember that whichever style you choose, you must remain consistent throughout the extent of your entire lab report. For more information, see "Citations in Writing Science" handout at http://carp.sfsu.edu/content/helpful-handouts.

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