

Student Guidelines for Writing a Formal Laboratory Report

Overview

An essential part of science is learning to communicate findings from a scientific investigation. Thus, preparation of a laboratory report in the form of a scientific paper is regarded as an important part of your learning. Formal laboratory reports are typically required in the sciences. A formal laboratory report is utilized either for writing up a given laboratory that you performed or for designing and conducting your own laboratory exercise.

These reports are an important mode of assessment and should represent your best work. Follow the content and format provided by your teacher and outlined below. There are 7 sections to the research report. Each section and the title are discussed separately in these guidelines. Specific attention is given to 4 essential writing elements including content, style, format and mechanics. In writing laboratory reports, you will find that these elements are closely linked to one another. These elements of writing are described below.

Content

In these guidelines, each section begins with a description of what content belongs in the section. Content has to do with the topic or subject matter that is to be reported in the section.

Style, Format and Mechanics

Each section of the guidelines provides suggestions about style of writing, format and mechanics. *Style* refers to the manner in which the section of the report is to be written. In writing a laboratory report, you'll find the style varies from section to section. For example, the introduction is written in formal style (expository) that includes drawing on previous scientific work and using proper citation of references. In contrast, the methods and procedures sections follow different, structured list-type writing style.

Format describes how the information in each section is to be organized and laid out. Because the style and format are related to each other, the format also changes with different sections of the research report.

It is expected that appropriate language *mechanics* (punctuation, grammar, usage, composition) will be used in writing the report. For each section, specific language mechanics are identified.

General Writing Considerations

Content

A formal laboratory report consists of the following elements:

- Title
- Abstract
- Introduction
- Materials
- Procedures
- Results
- Conclusions
- Literature cited

Style, Format and Mechanics

- Laboratory reports are typed or written in ink.
- Each section is clearly indicated with a heading centered in the middle of the page. Capitalize the first letter of all words in the heading except articles (a, the), short prepositions (3 or fewer letters), and conjunctions (and, or). These headings may be bolded if you like.
- Check for spelling and grammatical errors. There should not be any cross-outs in the text.
- The laboratory report reflects the objective qualities of the scientific process. Avoid using the more personal first person singular (“I”) or plural (“we”). The past perfect tense is preferred. The following is an example for writing sentences in the preferred past perfect tense without the use of the first person.

EXAMPLE

Preferred form written in past perfect tense:

“The results indicated that solution A had a higher concentration than solution B.”

Avoid this form using the first person:

“From this experiment I learned that solution A was more concentrated than Solution B.”

Title

Content

The title captures the laboratory's content in a few words. Indicative titles are preferred to informative titles. Indicative titles highlight the main point or conclusion. Informative titles simply state the subject of the article.

EXAMPLE

Preferred indicative title:

The Effect of Electromagnetic Fields on Migrating Whales

Less descriptive informative title:

Migrating Whales and Electromagnetic Fields

The title is phrased in a similar way to the research question, also known as the operational question. Clearly identify the independent variable (IV) and dependent variable (DV).

Recall that the independent variable (IV) is the part of the experiment that you are changing and the dependent variable (DV) is what is being measured as a result of that change.



HINT: Use this formula to create a scientific title.

The Effect of _____ [IV] on _____ [DV]

For example: The Effect of Exercise on Heart Rate

Format

- Center the title near the top of the page, just below the top margin.
- The first word is always capitalize (first letter upper case font).
- All key words except conjunctions, prepositions and articles are capitalized.
- Conjunctions (e.g., and, or) and prepositions (e.g., of, by) and articles (e.g., a, the) are not capitalized.
- If a specific species is used in the title, write the species name in italics.

Abstract

Content

The title of your report makes only the simplest statement about the content of the report. The abstract gives a general overview summarizing the purpose, methods, major findings and conclusions. Use concise sentences reflecting the major points from the laboratory. Although the abstract comes first, it is the last section that you will write because you need to know the results of your experiment and important conclusions first.

The following is a list of 5 elements that are needed in the abstract. Write each element in one or two sentences.

1. State the purpose. What was the purpose of the laboratory? That is, why was the experiment done?
2. State the predicted outcome. Was the prediction based on a scientific theory or law? If yes, identify the relevant theory or law. Then, state the research hypothesis or hypotheses.



HINT: Use this formula to write your hypothesis:

If _____ [IV] is _____ [*describe how it was changed*], then _____ [DV] will _____ [*describe the expected effect*].

For example: “If the antibiotic cleaning agent is placed on a bacterial colony, then growth of the colony will be inhibited.”

3. Summarize the methods, including only the major methods used. If a well known technique is used (e.g., gel electrophoresis), just state the name of the technique. The details about the technique will follow in the procedures section of the laboratory report.
4. In one or two sentences, highlight the major results. Start with a sentence beginning, “The major findings from this laboratory were...”
 - ❑ Only the key results are included in the abstract. Generally, this means reporting the final results from the calculations.
 - ❑ If an average of the data was calculated, report only the average not individual data points.
 - ❑ If class data are used for comparison, state the average or make a general statement about how they compare to your individual data points. The other data will be discussed in the results and conclusion sections of the report.
5. Summarize your major conclusions. Start with a sentence such as, “From the data, it can be concluded that...”

Style, Format and Mechanics

- Keep the abstract short, only 1 paragraph long.
- Single space the abstract.
- If you choose, this section may be enclosed by a border.

Introduction

Content

The introduction to the laboratory report includes a background discussion of the major concepts addressed in the laboratory. This section provides a brief, focused historical overview of the problem, definitions of terms related to the experiment and a statement of the purpose.

1. Clearly identifying the research topic being studied. Examples of sentences introducing the research topic include the following:

EXAMPLE

State the topic and identify major concept(s)

_____ [*state topic*] is the focus of this investigation. _____, the key concept underlying this major concept, is defined as _____.

3. The last sentence(s) of the introduction is the purpose statement. A clear way to start this sentence is to say, "The purpose of this experiment is to..."

Style, Format and Mechanics

- Write introduction using the present tense except when describing research completed in the past.
- Double-space the entire section.
- Key terms and definitions may be bolded.

Materials

Content

Everything essential for conducting the experiment is listed in the Methods section and substitutes are given. This includes naming the chemicals, specimens, equipment, glassware, software, etc. School supplies such as paper and pencils do not need to be listed. Like a recipe, your list of materials should include the *what* materials and *how much* of each are needed.

Style, Format and Mechanics

- Write materials in list format.
- Bullets may be used.
- More than one column may be used.
- Quantities of materials are listed after the material, i.e., NaCl, 20g.
- Use standard scientific abbreviations for measurements.
- Chemical formulas may be used, (e.g., NaCl for sodium chloride).

Procedures


Content

The Procedures section details the methods used in laboratory experiment. The procedures are detailed so that any other investigator can reproduce the process exactly. Procedures include a list of the steps to conduct the experiment, safety procedures, descriptions of apparatus, and specification of each condition under which the experiment was done. Also, included are diagrams of the experimental setup.

Style, Format, Mechanics

- This section can be written in one of two ways:
 1. If the procedure is taken from a laboratory manual then you can briefly summarize the methods. Be sure to include any deviations from the manual.
 2. If you and your partners design the procedure, then you must describe the procedure in detail such that another scientist could replicate your experiment
- Use a list format to describe the experimental steps.
- List safety warnings directly before the procedures or integrate warnings in the steps.
- Include a description of the proper disposal of specimens or chemicals.
- Include a diagram of the experimental setup.
 - Label all parts of setup, including apparatus and materials in the diagram.
 - Place diagram either to the right of the procedural steps or center in the text (see example below).
 - You may draw your own diagram or cut and paste a diagram from your laboratory manual, if provided.
- Single space this entire section.
- Write procedures using the past tense.
- Use complete sentences.

EXAMPLE

Experimental Setup for Carbon Testing	
Residue was removed carefully from the test tube prior to... ~~~~~ ~~~~~ ~~~~~ ~~~~~	

Results

Content

The Results section describes, in words, your observations (qualitative data) and the experimental data (quantitative data). It also includes the data displayed in tables and/or in graphs. Results describe only what was found or observed, just the facts. Interpretation of results is discussed in the Conclusion section.

Ways to describe data. Five ways to describe data may be reported in this section including tables, observations, sample calculations and graphs.

1. *Tables.* Organize the data from your experiment into charts or tables. Be sure to use a ruler if you are hand drawing the table or chart. Consider using a computer program such as Excel, SPSS or Word.
 - Record your numerical data and observations (scientific drawings, photographs, audio tapes, videos, written notes).
 - Use the proper metric units and use the “significant figures” to reflect the accuracy of the instrument used to obtain the data. This means that if you are using an electric scale that has an accuracy of 2 decimal places, then report your results using 2 decimal places. For example, report 3.00 grams, not 3 grams.
 - Describe the data in a few sentences. Remember to state the exact results, but do not make inferences or draw conclusions.

EXAMPLE

Table 1

Changes in Potato Mass Over Time

% Salt (NaCl)	Initial Mass (grams)	Mass at 5 min (grams)	Mass at 10 min (grams)	Final Mass at 15 min (grams)
0.5%	0.34	0.34	0.35	0.35
1.0%	0.37	0.37	0.38	0.39

The data listed above show the mass of 1 cm of potato cube over time. For the 0.5% solution, mass ranged from 0.34 g to 0.35 g from initial time period the final time period. In the 0.5% and the 1.0% salt solution, mass increased slightly over time.

2. *Observations.* Any observations made during the laboratory are reported in this section. Observations are descriptions or scientific drawings of findings that are not based on numbers. Examples include a growth appearing in a bacterial experiment or the color and height of a chemical responding to a flame. An observation is different from an *inference*; it describes what the object or event looks like, not the reason you think a change happened.
3. *Sample Calculations.* Displaying your calculations is an important way to show how you derived your data. When writing sample calculations, first show the formula or steps for the calculation, then show an example using the numbers. Box or underline your final answer. It is not necessary to show all calculations; one example of each type is

sufficient.

EXAMPLE

Table 2 *Percent Change in Mass*

% Salt	% Change in mass = (mass final – mass initial) x 100
1.0 %	% Change in mass = (0.39g – 0.37 g) x 100 % = 0.02 x 100 % = <u>2.0 %</u>
The change of mass at 15 minutes was calculated as the percentage change compared to the initial mass. In the 1.0% salt solution, the change was positive because mass increased.	

4. *Analysis.* Running programs with basic statistics are often helpful for summarizing your data and drawing conclusions from the data. Many calculators and computer programs can run simple statistics on your data. Helpful analysis may include

Measurement

- Average, Mean- measures the central tendency of the scores
- Standard Deviation- Measures the variability among the scores; accompanies the mean and provides an indication of the spread of the scores
- Probability- Measures the chance an outcome will occur. Determining probabilities are especially important for genetics problems.
- Percentage- Measures the part of the whole.

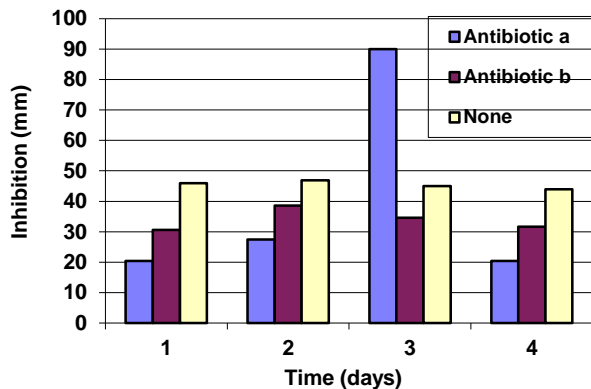
Statistics

5. *Graphs.* Graph data whenever possible. Relationships are more easily identified in a graphic presentation as compared to a table. Some data that cannot be graphed on coordinates can be expressed in pictorial form using other graphics such as a histogram. Supplement each graphic with a brief descriptive text following the general guidelines described above.
- The *title* of your graph should be centered and placed just above the graph. Label both the x-axis and the y-axis. Be sure to indicate the units used in the experiment. Multiple data points should be graphed to provide a comparison among the experimental conditions.

EXAMPLES

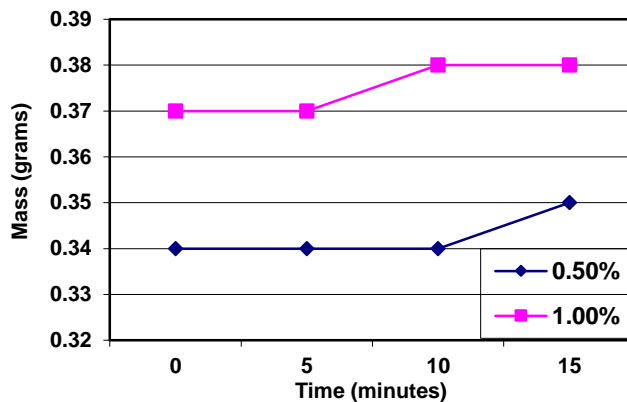
Bar Graph

Figure 1. Effect of Antibiotics A and B on Bacterial Growth



Line Graph

Figure 2. Mass of Potato vs Time



Style, Format and Mechanics

- Following the data in tables, sketches or graphs, describe the data.
 - State the general trend of the values (i.e., increasing, decreasing, remaining constant).
- Results should be written in past tense. This shows that the experiment has been completed.
- Write descriptions of results (from tables, observations, calculations, or graphs) in paragraph format, double-spaced.

Conclusion

Content

The Conclusion section is a summary and discussion of your experiment. This section is a challenge to write because it requires thinking critically about the findings and examining the relationship of the results to other experiments. Parts of the conclusion repeat other elements of your report. This is OK. A reader should be able to understand the entire experiment by reading only the conclusion.

1. Start the conclusion by restating the purpose and key methods used in the experiment.
2. Make a general statement indicating if the experiment had the predicted outcome.
3. Write several paragraphs that summarize your findings. Below are three key areas to be addressed.

Data Analysis. Use your data to discuss relationships or associations (when things tend to happen together) and cause and effect (when one thing causes another to occur). Refer to specific examples from your results to support these conclusions. These conclusions should directly relate to the objectives stated in the laboratory manual as well as the purpose statement.

- ❑ Some examples of ways to start key sentences include:
 - “The major findings in this experiment include...”
 - “A possible explanation for the findings is...”
- ❑ Compare your results and interpretations with those obtained by your classmates. State any major differences or similarities.
- ❑ Compare your results and conclusions with similar research conducted by other scientists. Tell how your laboratory results are linked to results reported by others.
- ❑ Include pertinent information from reference books, periodical literature, and other sources.
- ❑ Integrate responses to all questions asked in the laboratory manual.
- ❑ Limit your conclusions to statements that can be inferred directly from the results of your investigation. In other words, do not make inferences based on information that did not come from your specific laboratory results.

Error Analysis.

- ❑ First, identify any apparent errors or inconsistencies in your results.
- ❑ Use percent error or average percent deviation calculations to support your data.
- ❑ What caused the results to be inaccurate? Write a paragraph identifying and explaining possible sources of error and inaccuracies.

EXAMPLE

The results are not consistent with the research hypothesis. In addition, the results differ from those of my classmates [*describe what difference was, were your values higher or lower, different color, failure to grow, etc.*]. One explanation for this difference is that _____ [*explain what was done differently, or what may have happened, or where your procedures varied*]. This would have caused _____ [*explain how the difference in your procedures may have altered the results*].

- ❑ Account for unexpected results.
- ❑ Do not be afraid to admit where errors occurred. In science, mistakes can sometimes lead to important findings!

Application/Future Research.

- ❑ Include a brief paragraph discussing how the results from this laboratory experiment relate to everyday or “real world” situations. For example, if you were examining bacterial growth, you could extend your discussion to the issue of sanitation in hospitals or meat factories. Tell how the experimental results could be used to control sanitation problems.
- ❑ Think of ways to improve your experiment. For example, maybe there is another way to carry out the experiment using other environmental conditions. How would this procedure produce different results?
- ❑ Write about how your experiment raises other research questions or how it could be extended to other situations. Think of related problems that could be researched. For example, if you were studying bacterial growth, what factors might promote or hinder bacterial growth. Think of a new hypothesis that could be tested and include these ideas.

Style, Format and Mechanics

- This section should be double spaced.
- The conclusion should be written in present tense.

Literature Cited

Content

The Literature Cited section is a compilation all references cited in the body of your laboratory report.

Style, Format and Mechanics

- Arrange references in alphabetical order of last name of first author.
- If you have more than one paper for the exact same author(s) arrange chronologically from older to more recent papers.
- Use the following selected list of types of references to format your references. This should be done according to the APA style (Higgins, 1990). If the style of your source is not listed, reference your *Writers Inc.* text.

Books

One author	Seagrave, L. (1988). <i>The discovery of DNA</i> . New York: Harper & Bow.
Two authors	Andrews, D.C., & Andrews, W.D. (1988). <i>The science connection</i> . New York: Macmillan.
Three authors	Allen, R. R., Brown, K. L., & Yatvin, J. (1988). <i>The animals of the desert</i> . Belmont, CA: Wadsworth.
More than three authors	[Same form as for three authors. Give names of <i>all</i> authors.]
Editor	Johnson, S. (Ed.). (1975). <i>The population problem</i> . New York: Wiley.
Edition	Chenfield, M. B. (1987). <i>Teaching science creatively</i> (2nd ed.). San Diego: Harcourt Brace Jovanovich.
Book of several volumes	Greenstein, F. I., & Poisby, N. W. (Eds.). (1984) <i>Handbook of environmental science</i> (Vol.2). Reading, MA: Addison-Wesley.
Bulletin or government publication	National Institute on Drug Abuse. (1979). <i>Research issues update, 1978</i> (NIDA Research Monograph No.22). Washington, DC: U.S. Government Printing Office.

Encyclopedia Articles

Signed or initialed	George, B. J., Jr. (1983). Jurisdiction. In S. H. Kadish (Ed.), <i>Encyclopedia of biological terms</i> . (Vol.3, pp.922-926). New York: Free Press.
Unsigned	Barometric light. (1986). <i>Encyclopedia Americana</i> (Vol.3, p.258). Danbury, CT: Grolier.

Periodical Articles

Magazine article (signed)	Tifft, S. (1988, November 14). Pros and cons of genetic engineering. <i>Time</i> , pp. 55-64.
Magazine article (unsigned)	Marine Mammals. (1988, November 14). <i>Time</i> , p. 50.
Journal article	Weins, J. W. (1983). Tn5 and crown gall tumors. <i>Journal of Biochemistry</i> , 16, 144-149. [Note: 16 = vol. 16]
Journal article (new paging each issue)	Coleman, E. B. (1983). Writing in the sciences. <i>Science and Technology</i> , 1(3), 36-38. [Note: 1(3) = vol.1, issue no.3]
Newspaper article	Lewis, F. (1988, November 9). The migration of monarch butterflies. (signed)

- New York Times*, p. A35. [Note: A35 = section A, p.35]
- Newspaper article or Editorial (unsigned) Swarm of "killer" bees found in Florida port. (1988, November 9).
New York Times, p. A14.
- Computers**
- Computer software Roney, M. L., & O'Brien, T. C. (1985). *Planetary construction set: Discoveries in science* [Computer program]. Pleasantville, NY: Sunburst Communications.
- World Wide Web Burka, L.P. "A History of Women in Science." *Science Today*.
<http://www.astr.ua.edu/4000WS> (5 Dec. 1994)

Student Name(s) _____
Formal Laboratory Scoring Rubric
Teacher Evaluation

The following rubric will be used to score a lab report. Read the entire laboratory report and fix any grammatical or spelling errors. Pay close attention to the comprehensibility the writing. Is the report easily understood? Are all of the requirements met? Are you talking in present tense? Using the rubric, confirm that you will achieve the desired score.

Title _____ / 2

- 2 Title is indicative and variable are included.
- 1 Title is not indicative and variables are not included.

Abstract _____ / 3

- 3 Abstract contains all 5 components. Sentences are concise and highlight only the major points.
- 2 Abstract contains 3 or more components. Sentences are somewhat concise and most of the major points are addressed.
- 1 Abstract has 3 or less components. Sentences are wordy and the points are either not the major points or they are irrelevant.

Introduction _____ / 3

- 3 Introduction references several sources. The material referenced is pertinent, thorough and incorporated well into the text.
- 2 Introduction contains references that generally relate to the laboratory. Transitions between ideas from references maybe slightly choppy.
- 1 Introduction contains weak, not applicable or very few references. Information and concepts from references is not well integrated.

Materials _____ / 2

- 2 Materials list is complete and accurate.
- 1 Materials list is not complete; missing one or more necessary materials for the laboratory.

Procedures _____ / 2

- 2 Steps are accurate and complete and diagrams are used.
- 1 Steps are mostly complete and clear. Diagrams used are weak or absent.

Results _____ / 4

A. Data

- 2 Tables and observations are neat and labeled properly. Sample calculations are accurate.
- 1 Tables and observations are somewhat neat and labeled properly. Sample calculations are accurate. Text accompanies data.

B. Graphs

- 2 Graphs accurately reflect data from the laboratory. Graphs are labeled with appropriate units, have titles, are well spaced.
- 1 Graphs accurately reflect data from the laboratory. Details on graphs is not complete.

Conclusion _____ / 7

A. Purpose

- 1 Purpose and methods are briefly summarized. Mentions consistency of data with hypothesized outcome.

B. Data Analysis

- 3 Data analysis shows thoughtfulness and thoroughness. Specific examples of data are compared and correlations are made. References to class data are incorporated. Applicable references are used as a comparison of data.
- 2 Specific examples of data are compared and correlations are made. References to class data are incorporated. Applicable references are used as a comparison of data.
- 1 Does not contain many comparisons of and correlations between data. References to class data are weakly or not incorporated. References are used but comparison of data is weak or insufficient.

C. Error Analysis

- 2 Error is correctly identified and concrete examples are provided to account for discrepancies in the laboratory. Logical explanations follow each example.
- 1 Error is identified and examples are provided to account for discrepancies in the laboratory.

Literature Cited

_____/ 2

- 3 All references used in the text are cited and visa versa. No information is missing from any of the references. All information is properly cited within the text.
- 2 All references used in the text are cited and visa versa. Very little information is missing from any of the references. Most of the information is properly cited within the text.
- 1 Most references used in the text are cited and visa versa. Some information is missing from the references. Information from other sources is not properly cited in the text.

Mechanics

_____/ 2

- 2 Report contains less than 5 spelling or grammatical errors.
- 1 Report contains more than 7 spelling or grammatical errors.

Style, Format and Mechanics

_____/ 5

- 5 Proper scientific format is used in all sections. (ex. Past tense)
- 3 Proper scientific format is used in most sections.
- 1 Proper scientific format is not used in most sections.

Total Score

_____/32