TCS Writing Centre

Formal Lab Reports

The purpose of writing a lab report is to show how well you (a) performed your investigation, (b) understood what happened during the process, and (c) can convey that information in an organized fashion. **You may have worked with a lab partner on a lab, but the work you do and present in a lab report should be your own.**

TITLE

- ❑ The title should describe what you have studied. For example:

  "The Effects of Light and Temperature on the Growth of the Bacterium, *E. coli*"

  This title explains the environmental factors manipulated (light and temperature), the parameter measured (growth), and the specific organism used (*E. coli*).

INTRODUCTION

Why did you study this problem? **The introduction should identify the problem or issue and provide the background information that the reader needs to understand your experiment.**

- ❑ Provide the **BACKGROUND INFORMATION** (on previous work and/or theories).
- ❑ The introduction should end with a **PURPOSE STATEMENT** (sometimes in the form of a hypothesis or null hypothesis): one sentence which specifically states the question your experiment was designed to answer.

The purpose of this investigation was to determine effects of environmentally realistic exposures of acid precipitation on productivity of field-grown and chamber-grown peanuts.	The hypothesis was that environmentally realistic exposures of acid precipitation would affect the productivity of both field-grown and chamber-grown peanuts.	The null hypothesis was that environmentally realistic exposures of acid precipitation would not affect the productivity of either field-grown or chamber-grown peanuts.
As a purpose statement.	**As a hypothesis.**	**As a null hypothesis.**

- ❑ A rationale may be provided for your hypothesis.
- ❑ Use the present tense for the information in the Introduction (for current or accepted theory) and the past tense when stating the hypothesis/purpose.
- ❑ Include references in this section.

MATERIALS & METHODS

What did you do? **This section describes experimental design, experimental apparatus, methods of gathering and analyzing data, and types of control. It is written clearly and in enough detail to allow readers to duplicate the experiment if they wish.**

- ❑ Use the passive voice to describe what you did (e.g., "Six petri plates were filled with agar").

Experimental Design:

- ❑ Explain what you changed between groups. This is the **INDEPENDENT VARIABLE** (manipulated variable). List the levels of the independent variable that you included in your experimental protocol. If you performed a descriptive study rather than true experiment, explain why no variable was manipulated.

- ❑ Explain what was measured. This is the **DEPENDENT VARIABLE** (responding variable). List what was measured (both qualitative and quantitative data) and explain how it was measured.

- ❑ At least three relevant **CONTROLLED VARIABLES** are required, but more may be necessary. You need to control for all variables that may reasonably affect the outcome of the investigation. **Materials used and measurement techniques are NOT controlled variables** (they are validity measures). While materials and techniques must be consistent, a true control variable is something that could directly influence the responding variable, not just how it is measured. Explain why and how variables were controlled.

Procedure:

- ❑ Explain the **PROCEDURE** you used in the experiment. Use complete sentences; do not write in the form of instructions or as a list of materials. Methods adapted from other sources should be referenced.

- ❑ Your procedure must **CLEARLY STATE HOW YOU COLLECTED DATA**. What measuring device did you use, what data did you record, when did you collect data, and what qualitative observations did you look for?

- ❑ Your procedure must include a few **VALIDITY MEASURES** (e.g., cleaning test tubes prior to use, cleaning the microscope lenses, using the same ruler, etc.). Validity measures are things kept constant to make sure experimental measurements are valid and consistent.

- ❑ Include a **DIAGRAM OR PHOTOGRAPH** of how you set up the experiment. Be sure your diagram includes a title and any necessary labels. It is recommended that this be annotated to illustrate how the variables were involved.

- ❑ If feasible, explain how the investigation ensured **MULTIPLE TRIALS** of data collection. As a rule, the lower limit is a sample size of five. Very small samples run from 5 to 20, small samples run from 20 to 30, and big samples run from 30 upwards. This will vary within the limits of the time available. If you **COMBINE DATA** with data collected by other students, you should indicate that "pooling data was done to ensure collection of significant, relevant data." If you **SAMPLED** only a portion of a population, you must explain how and why you ensured that the sample was randomly selected.

RESULTS

What did you find? **In the results, you present your observations and data with no interpretations or conclusions about what they mean. A well-written and well-organized results section will provide the framework for the discussion section.**

- ❑ Use <u>past tense</u> to describe your results. Use <u>subheadings</u> to organize the information presented.
- ❑ The written **TEXT** forms the main body of the results section within which tables, graphs, and photos may be included. The written text of the results section **may** be as short as one sentence summarizing the highlights and directing the reader to specific tables and figures.
- ❑ Avoid explaining the data in the results section since this is meant for the discussion.

> "The temperature increased during the second phase" (Results statement) **NOT** "The temperature increased during the second phase because of the drug treatment" (Discussion statement).

- ❑ **TABLES AND GRAPHS** should be used to supplement the text and to present the data in a more understandable form. Raw data will probably be most effective in table format, with the highlights summarized in graph form.
- ❑ Describe any **STATISTICS** used to analyze data (such as mean, range, percent change and standard deviation, t-tests, Chi-Square tests, etc.).
- ❑ Provide sample or detailed **CALCULATIONS** in a separate section titled "Calculations" or in an Appendix at the end of the report.

GUIDELINES FOR INCORPORATING TABLES AND FIGURES EFFECTIVELY INTO YOUR REPORT

1. Tables are referred to as **TABLES**, and all other items (graphs, photographs, drawings, diagrams, maps, etc.) are referred to as **FIGURES**.
2. Tables and figures must be **NUMBERED** in the order they are mentioned in the text. Tables and figures are numbered independently of each other.

> Tables 1 and 2, then Figures 1 and 2.

3. Self-explanatory **TITLES** located beneath tables and figures are included so that the reader can understand their content without the text.

> *Table 1. Percent of soybean plants exhibiting visible injury after exposure to acid precipitation.*

4. Each table or figure <u>must</u> be **INTRODUCED WITHIN TEXT**, with a comment that should point out the highlight(s) or significant trend(s), not every piece of data that is shown.

> *The plant increased in height over a 4-day period (Figure 1).*

DISCUSSION

What does it mean? How does it relate to previous work in the field? **Explain what you think your data mean and how it relates in the context of other scientific knowledge.**

- ❑ Use past tense when describing your results and present tense when comparing to current theory.
- ❑ Use subheadings to organize the information presented.

Conclusion:

- ❑ **DRAW CONCLUSIONS FROM YOUR RESULTS**. Your conclusion should be clearly related to the research question and the purpose of the experiment.
- ❑ **ACCEPT OR REJECT YOUR HYPOTHESIS**. Provide a brief explanation as to how you came to this conclusion using evidence from your results. In other words, sum up the evidence and explain observations, trends or patterns revealed by the data. **Avoid** using words such as PROVES, CORRECT AND RIGHT in your conclusions.
- ❑ **COMPARE YOUR RESULTS** to trends described in the literature and to theoretical behaviour.
- ❑ **CITE LITERATURE** related to your conclusion. Does you result coincide with published results? Does it refute published results?

Evaluating Procedure:

- ❑ Describe your **CONFIDENCE** in the results. Are your results fairly conclusive, or are other interpretations/results possible? What did you do to make sure your results are valid? Note that if you only did the experiment once, and on a very small sample, you may have evidence supporting your hypothesis, but you have not *proven* anything.
- ❑ Identify and discuss significant **ERRORS** that actually affected your data collection. Identify the source of error and if possible, tie it to how it likely affected your results. Avoid hypothetical errors ("could have" or "I might have") without evidence to back it up. Common errors include:
  - **Human error:** Human error can occur when tools or instruments are used or read incorrectly. Human errors can be systematic because the experimenter does not know how to use the apparatus properly or loses concentration. Automated measuring using data-loggers can help reduce this error.
  - **Calibration error:** Some instruments need calibrating before you use them. If this is done incorrectly it can increase the risk of systematic error.
  - **Random errors:** In biological investigations, the changes in the material used or the conditions in which they are carried out can cause a lot of errors. Biological material is notably variable.

- **Measurement uncertainty errors:** Could be due to the equipment selected.

- **Uncontrolled variables:** What variables were not controlled? What effect might each of these uncontrolled variables have had on your data? On the conclusion?

- ❑ What are the **LIMITATIONS** of your conclusion? Can the results be generalized to other situations/conditions? How might your results explain a process in the "real world"?

- ❑ What **IMPROVEMENTS** can be made to the investigation? Suggestions for improvements should be based on the errors and limitations identified just identified.

- ❑ The concluding sentence should be written clearly and related directly to the hypothesis.

REFERENCES & CITATIONS

Give credit where credit is due! Scientific lab reports are written for the sole purpose of sharing information. If readers want more information about something, they need to be able to find the exact place it was originally written. References also give credit to the person who did the work and provide your work with authority. References used are **papers and resources actually mentioned** (cited) within the report. A "Bibliography," on the other hand, refers to a list of all materials used to get background knowledge on a subject (you will not usually be required to include one in a scientific lab report).

- ❑ ALL information within the report that is not your original work or ideas should be referenced (even if not quoted directly, but paraphrased or summarized – quotations are rare in scientific writing).

- ❑ Use **IN-TEXT CITATIONS** within the sections of the report and a **REFERENCE LIST** provided as a section on a separate page at the end of the report using the heading "Literature Cited".

In-text citations usually occur in one of two places in the sentence: *Smith (1999) has also found that E.coli is one of the only microbes to . . . .* or *E.coli is one of the only microbes to . . . (Smith 1999)*.

- ❑ References and citations should be in APA formatting. Please see planner for complete guide.

FINAL REPORT FORMATTING

- ❑ Heading of first page: title, your name, lab partners, date of report.

- ❑ The final report must be typed with 1.5 spacing.

- ❑ Do not write in first person singular (don't use 'I', 'we', 'he', etc.).

- ❑ Use the past tense when describing your purpose/hypothesis, methods, results

- ❑ All headings and subheadings should be in boldface or underlined.

- ❑ Attach your original raw data collection table at the end of your report.

CHECK LIST FOR LAB REPORT

☐ Did you have an appropriate title?

☐ Have you included background information related to your hypothesis?

☐ Have you used citations (in APA format) in your introduction?

☐ Have you identified all the manipulated and responding variables?

☐ Have you stated the experimental and control treatments?

☐ Have you identified the control variables and validity measures?

☐ Have you described the procedure used?

☐ Are your data tables and graphs formatted properly?

☐ Are tables, graphs and diagrams labeled using figure legends?

☐ Have you highlighted significantly different data?

☐ Have you supported or rejected your hypothesis with data and statistical support?

☐ Have you connected your findings to known scientific literature, with citations?

☐ Have you discussed the confidence in your data in your conclusion?

☐ Have you discussed errors affecting your results?

☐ Have you made mention of limitations and improvements that can be made?

☐ Have you included your "Literature Cited" in APA format?

☐ Have you checked that the tenses within your paper have been used appropriately?