Name Period Date

How to Write a Lab Report

Biologists continually make observations about the natural world around them, raise questions about their observations, and design and perform experiments based on these observations. After completing an experiment, they write a report that describes what they did, what they intended to accomplish, and why. A lab report summarizes

- the purpose of the investigation or experiment;
- the entire process of the experiment, step by step;
- the results; and any conclusions or findings that they drew from those results.

Science is a process, and the lab report is one way this process is communicated. Lab reports add to the sum of knowledge about a subject in the scientific community, create a "road map" so that other scientists can repeat the results of the experiment, and provide a starting point for future study.

For you, the lab report will demonstrate your understanding of the scientific concepts, show that you know how to conduct an experiment properly, and communicate to your teacher, and possibly also to your classmates, what you have learned.

This section explains how to write a lab report, including the various types of information that are expected to be in it and the structure that you should use. Concentrate on using simple, clear, descriptive language and organizing your ideas logically.

Purpose

A laboratory investigation always has a purpose. Sometimes the purpose has been given to you by your textbook or lab manual; in other cases, you may have to determine the purpose of your experiment based on your own observations or readings. The **purpose** statement in your lab report raises the question or problem that you sought to investigate via the experiment.

EXAMPLE

How does fertilizer affect plant growth?

Hypothesis

A **hypothesis** is a tentative explanation for an observation that leads to testable predictions of what would happen if the hypothesis were valid. An observation can lead to many different questions or hypotheses, but you should have chosen just one to study in your experiment.

The hypothesis is often written in the form of an "If…then…" statement.

EXAMPLE

If plants need the nutrient nitrogen for growth, then plants given fertilizer that contains nitrogen will experience an increase in growth.

Note: An experiment is designed to test a hypothesis, and data from the experiment can only support or fail to support the hypothesis. Therefore, be careful that your lab report does not say that your experiment proves or disproves the hypothesis. Often scientists can learn more from experiments whose data does not support the hypothesis.

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Materials and Equipment

Your report should include a list of the materials and equipment that you used to perform your experiment. Make sure that your list is complete and includes all the necessary details—such as measured amounts of substances—so that someone else can perform the same experiment. Any modifications that were made to equipment should be noted in this section.

EXAMPLE

Materials List

30 g fertilizer

3 potted plants of the same species

100-mL graduated cylinder

Variables and Constants

All experiments include constants and variables.

- **Constants** are all the factors that are kept the same during the entire experiment, while variables are factors that change.
- The **independent variable** is the factor that you are deliberately changing.
- The **dependent variable** changes as a result of the experiment.

EXAMPLE

- **Independent variable**–amount of fertilizer with nitrogen
- **Dependent variable**–plant growth
- **Constants**–temperature, amount of light and water, frequency of watering, type of soil

Control and Experimental Groups

Another element of the experiment that needs to be featured in your lab report is the definition of your control and experimental groups. An experiment that determines how two factors are related always has a control group and one or more experimental groups.

- The **control group** is exactly the same as the experimental group or groups, with all the same constants—except for the factor that the experiment is designed to test.
- The **experimental group** or groups feature the factor being tested.

EXAMPLE

In the plant growth experiment, there would be a control group, with plants that are not given any fertilizer, and one or more experimental groups, with plants that have received specified amounts of nitrogen-based fertilizer.

You also will need to define exactly how you are measuring the different amounts of plant growth—that is, are you comparing the plants' height, the width of their stems, or the size of their leaves? Generally, you should select only one growth factor to measure. Your lab report needs to describe the groups, what is different about them, and compare the amount of plant growth in each group.

Procedure

The **procedure** section of your lab report describes all the steps in your experiment, in the exact order that you performed them. Again, the steps should be listed as clearly and in as

much detail as possible so that your experiment could be replicated. Number each step, and try to start each step with an action verb.

If your experiment involved control and experimental groups, you need to explain what you did to each group, and emphasize what was done in the same way and what was done differently.

The procedure section of your report should include references to the particular equipment or materials used in each step of the experiment. Often, a clear sketch of the experimental setup will help the reader understand how you carried out the experiment.

Observations and Data

This portion of your report should include all the observations and data that you noted while conducting your experiment. Observations include anything you noticed using your senses; that is, what you saw, touched, heard, and smelled. Taste, however, is an exception. You should never taste anything in a laboratory.

Data comes in two types: qualitative and quantitative.

- **Qualitative data** are descriptions of the dependent variable, such as color or sound; or simple "yes-or-no" observations about whether something happens, such as whether a plant grows.
- **Quantitative data** are numerical measurements of the dependent variable. These can include measurements of size, mass, frequency, temperature, rate, and many other factors.

Qualitative data are useful, but they can't be statistically analyzed. You can include them in your lab report, but remember that your experiment can't be based on qualitative data alone.

Observations and data may be written in a paragraph, a data table, a chart, or any other appropriate format. If you are using numerical data, you should always write them with an appropriate number of significant figures.

Most experiments require that you construct at least one data table. The organization of a data table will depend on the information that goes into it, but the general format is as follows:

- Each column of the table represents a particular variable or observation. Each column should be labeled clearly to show what its corresponding segment of data represents. The column labels should feature the units associated with the variable, if any.
- The rows of the table should represent the various trials performed during the experiment. Each row should include some means of identifying a particular trial. This is useful when writing the analysis and conclusion sections of the report.

EXAMPLE

TABLE 1. PLANT GROWTH IN CONTROL GROUP

Day	Plant 1 Height (cm)	Plant 2 Height (cm)	Plant 3 Height (cm)
0	12.40	11.30	11.90
3	12.45	11.40	12.20
6	13.25	12.00	13.10
9	14.75	12.75	14.25
Total	2.35	1.45	2.35

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TABLE 2. PLANT GROWTH IN EXPERIMENTAL GROUP			
Day	**Plant 1 Height (cm)**	**Plant 2 Height (cm)**	**Plant 3 Height (cm)**
0	11.60	10.015	10.00
3	12.80	11.00	11.50
6	14.00	12.20	11.90
9	15.85	14.15	13.00
Total	4.25	4.00	3.00

If something went wrong during your experiment, it is very important to describe that. If you don't follow the intended procedure exactly, errors can result, and you will need to explain the reason for the errors and their effects later in your report.

Data Analysis

Once you have collected, listed, and organized your data, the next stage of your report is to analyze it. Do the data support the hypothesis behind the experiment, or do they contradict it? You can't answer that question by just looking at a list of numbers or other data and guessing at what they show. You need to look at the data systematically and see what conclusions you can draw from it. Without analyzing your data, you will not be able to develop reliable conclusions.

Look at the raw data from your experiment and see how all the facts fit together. Calculate the mean, median, mode, and range for each group in the experiment. Use whatever types of statistics are appropriate for your data. If you use an equation to perform a calculation, you should show the equation and include all the steps of the calculation. Make sure that you identify the meaning of all the symbols you use and how they relate to your data. Use a sample calculation from your actual data as an example of your calculations in general during the experiment. Remember to use correct rounding rules and significant figures when performing your calculations.

Results

You can use data tables to show the results of your calculations for each trial. This allows you to present a large amount of information in a relatively small space. For certain types of investigations, you can construct graphs from the information contained in your data tables. The type of graph used will depend on the type of experiment and the comparisons you wish to make with your data.

A line graph is used to show trends, while bar graphs are used to compare sets of data. Look for ways to most accurately and effectively show your results. For example, you might make a graph to show and compare the groups' means in one place, or you might choose to make a separate graph for each group's results. When possible and applicable, use spreadsheet software to present your data.

This section is also the proper place to discuss anything that happened during the experiment that departed from the planned procedure, as mentioned earlier. Such occurrences may have affected your data, and information about these occurrences may help explain why a particular experiment did not produce the expected results.

The last part of this section should include a summary of your findings. This summary should include only results based on your data. Do not include anything unrelated to your data, even if they support your result or you think they are otherwise relevant. Your report should cover only the results of the particular experiment that you conducted.

Conclusions

In this part of your report, you state what you believe the experiment showed about the questions that you stated at the beginning of the report. Compare your results with your hypothesis to determine whether your results support it. Discuss what your results indicate about a relationship between the independent variable and the dependent variable. The answers you give should relate to the hypothesis and be based solely on the results that you obtained. As with the summary of your findings, your conclusions should be directly related to your results and should not involve outside factors.

EXAMPLE

Adding a fertilizer with nitrogen to soil tends to increase plant growth. Both high and moderate amounts of fertilizer tend to increase plant growth more than a low amount of fertilizer. However, high and moderate amounts of fertilizer appear to have the same effect on growth.

It is important to draw conclusions about your results, but don't make inferences about factors that you did not test in the experiment. Do not dismiss a conclusion just because it seems unlikely to you. You should only dismiss a conclusion if the observations from your experiment do not support it.

Because no experiment is absolutely perfect, you will have experimental errors. The conclusion section of your report is another place to discuss experimental errors, particularly in terms of their effect on the results. Part of your conclusion can be about ways that these errors could have been reduced or eliminated by a change in procedure.

Further Research

You may find that there are several possible answers that could explain your results. This does not necessarily mean that your experiment was flawed; rather, it can be a natural characteristic of scientific research. In science, the value of experiments can lie as much in the new ideas and further research they inspire as in their actual results. This is a key part of the scientific method.

If you discover that your experiment has led to further questions, list them all and discuss them briefly. Then suggest which of them, if any, could benefit from being investigated in a new experiment.