Directions

Write a lab report for this lesson's lab. Be sure that your report:

- includes all major elements of a lab report.
- meets your teacher's content and format expectations.
- is clearly organized and formatted.
- demonstrates strong scientific reasoning and writing.

While writing, you can revisit previous parts of the lesson by returning to the course map. Be sure to refer to the lab's student guide, which you can access from a link in the lab experiment activity. You may also find it helpful to refer to the remaining pages of this guide, which provide general guidelines for writing lab reports.

You can upload your completed report with the upload tool in formats such as *OpenOffice.org*, Microsoft Word, or PDF. Alternatively, your teacher may ask you to turn in a paper copy of your report or to use a web-based writing tool.

Lab Report Checklist

Introduction

- Did you title your lab report?
- Did you state the purpose of the experiment?
- Did you state the question you posed before the experiment?
- Did you restate the hypothesis (or prediction) you formulated before the experiment?
- Did you list all variables and label the independent and dependent variables? Did you indicate any controlled variables?

Materials and Procedure

- Did you make a list of materials? Did you include quantities and SI units?
- Did you present the steps of the procedure as a numbered list?
- Did you note any changes to the original procedure?
- Did you identify your experimental and control groups?

Data Collection and Organization

- Did you organize all data in a clearly labeled table and/or graph?
- Did you check that your data is accurate and complete?
- Did you title any tables and graphs? Did you label rows, columns, axes, etc., and include units?

Analysis and Conclusion

- Did you interpret your data and graphs in the analysis rather than just restate your findings?
- Did you determine whether your data supported or refuted the hypothesis?
- Did you describe possible sources of errors?
- Did you suggest ways to improve or further your lab investigation?

Overall

- Did you make sure that your writing is precise, unbiased, and concise?
- Did you meet your teacher's content and format expectations?

Overview

The Purpose of Lab Reports

When scientists make discoveries, they write reports to share their discoveries with the world. Likewise, after you complete an experiment, you can write a report to share what *you* discovered.

Writing a lab report is an important skill because it helps you demonstrate what you learned in a science experiment. It also helps you practice writing accurately and clearly about technical things—a skill that is valuable in the real world.

This guide describes the format and style of lab reports. It has many tips that will help you write stronger lab reports. Use it as a reference throughout your science studies.

Lab Report Format

Although the format of lab reports varies somewhat, it typically includes all of the following components in the order shown.

Section	Category	Page #
Part 1	Introduction (Title, purpose, question, hypothesis, variables)	3-4
Part 2	Materials and Procedure	4
Part 3	Data Collection and Organization	5
Part 4	Analysis and Conclusion	6

Later pages in this guide provide additional detail.

Science Writing Style

Science writing is different from other styles of writing you may be familiar with, such as persuasive writing and narrative writing. As with all types of writing, science writing has its own style; it is both precise and objective.

Science writing is precise. Be concise, but use descriptive language and specific details to help readers "see" what you observed. For example, a student who observes the presence of bubbles in a liquid during an experiment may write "The liquid had bubbles." This sentence is concise, but it doesn't tell the reader what kind of bubbles the student saw. Two precise alternatives follow:

- "The liquid had small bubbles—the size usually seen in soda."
- "The liquid produced bubbles the size of grapes or marbles."

Science writing is objective. Avoid bias and subjective descriptions such as "The liquid had huge bubbles." Also, use the third-person voice and avoid personal pronouns such as *I, we, you, he, she,* and *they*. This will allow readers to focus on the scientific topic without being distracted by thinking about the person who did the work.

Writing this way takes practice for most students. At first, your writing may sound formal or stiff to you. But in time, your writing will become clear and precise.

Part 1: Introduction

Title

Title your lab report with a few words that summarize the lab investigation.

Purpose

The lab report should begin with one or two sentences that state the purpose of the investigation—what you want to see, practice, learn about, or test. The purpose statement answers the question “What am I trying to find out by doing this experiment?”

The three most common types of labs are:

- **inquiry labs**, in which you measure how changing one variable affects another variable.
- **discovery labs**, in which you observe a scientific phenomenon, perhaps for the first time.
- **forensic labs**, in which you gather and analyze data as evidence to build an argument in response to a question, as in a court case.

All three types of labs give you an opportunity to learn important scientific skills and concepts.

Question

At its core, science is about inquiry, or the act of asking questions and seeking answers. Most labs begin as the result of a question, which is why the introduction of your lab report should include a question. For example, suppose you notice that you seem to play basketball better at the court in one park than in another. After conducting research, you realize that the surfaces of the courts you play on differ. As a result, you might formulate the scientific question “What effect does the court surface have on the height that the basketball bounces?” To answer this question scientifically, you could perform several experiments and gather data.

Hypothesis (or Prediction)

A hypothesis is an initial answer to a question, a possible explanation or expectation based on prior knowledge or research. Before starting most labs, you will formulate a hypothesis. It should be listed in the introduction of your lab report.

A good scientific hypothesis states conditions, expected results, and possible reasons for those results. For example, you could respond to the basketball question with a hypothesis like "If the court surface is smooth concrete, as the park's court is, then the basketball will bounce higher, because smooth surfaces have better contact with the ball." Like this hypothesis, hypotheses are often structured using the format "If . . . then . . . because . . .," which is described below.

- The "if" portion of the hypothesis describes something that you will change in the experiment.
- The "then" portion of the hypothesis describes what you think will happen as a result of that change.
- The "because" portion of the hypothesis describes the reason why you think that change will occur.

In other laboratory activities you will be asked to make a prediction. You will conduct background research, then predict the outcome of a known scientific process.

Special Note about Inquiry Labs

For inquiry labs, **questions** are generally written in the form of "What is the effect of X on Y?" **Hypotheses** will generally be in the form "If X [describe how you will change X during the experiment], then Y will [predict how Y will change in response], because [give your reason]." In many inquiry labs the variables lend themselves to a scatterplot (X-Y plot).

Variables

The last part of the pre-lab information section of your lab report should be a description of the variables. There can be up to three types of variables, each of which is described below.

- **Independent variable (IV):** This is the factor that is directly manipulated in the experiment. It is sometimes called the manipulated variable. In the traditional format for a hypothesis, "If X . . . then Y," the independent variable is X.
- **Dependent variable (DV):** This is the observable factor that varies due to changes to the independent variable. It is sometimes called the responding variable. In the traditional format for a hypothesis, "If X . . . then Y," the dependent variable is Y.
- **Controlled variables:** These are variables that could affect the dependent variable, but which you prevent from changing during the experiment. By holding other variables constant, you can focus an experiment on the relationship between the independent variable and the dependent variable.

Part 2: Materials and Procedures

Materials

List all of the supplies you will need to conduct the experiment. Include the names of the materials, quantities, SI units, and even brand names if the brand may have affected your results.

Procedure

Create a numbered list summarizing the steps you carried out in completing the lab. If you made any changes to the original instructions in the student guide (either on the advice of your teacher or on your own), be sure to identify them. Describe each step using accurate, concise language so that someone who has never performed the experiment could repeat it. Be sure to include details about any apparatuses and materials that you used, especially if you made substitutions to the apparatuses and materials described in the student guide for the lab.

Groups

Laboratory procedures sometimes are based around the following two kinds of groups:

- **Experimental group:** This is the group in which one condition (variable) is changed. Its response is compared with the response of the control group.
- **Control group:** This is the group that is identical to the experimental group but in which the independent variable is not changed. It provides a baseline for comparison.

Trials: For some labs, you will repeat the experiment to collect additional sets of data. By performing additional trials, you can refine how you execute the lab procedure, increase accuracy, and avoid one-time results. Instead of performing additional trials, you may be able to combine your data with other students' data if you are all performing the same experiment.

Part 3: Data Collection and Organization

While doing the lab procedure, you collected data on a data sheet or in your lab notebook. Your lab report should display that data in formal tables or graphs. Use the descriptions below to choose the display that makes your data clear to the reader and reveals what is important about the data.

Tables: Be sure to label each column and row in the headers. Quantitative data should include all measurements and calculations, including correct SI units of measurement. Make sure that units are consistent and that you use an appropriate number of significant figures. Qualitative data should include descriptions of what you saw, heard, felt, or smelled during the experiment. (See the sections titled "Science Writing Style" and "Variables" for more guidance.)

Bar graphs: Use these graphs to compare two or more sets of conditions or categories.

Histograms: Use these bar graphs to show the frequency of ranges of values.

Line graphs: Use these graphs to show the change in one variable as a second variable is changed. Typically, the individual data points are plotted, and then lines are added to show trends. A line segment that connects two points on the graph provides a slope, which can be interpreted as a rate that measures how one variable changes relative to another. This slope has a mathematical formula. These graphs can be very helpful when you want to look at changes over time.

Pie graphs: Use these graphs to show percentages or parts of a whole.

Scatterplots: Use these graphs to show each pair (x, y) as a point in the coordinate plane. They differ from line graphs in that individual points are not sequentially connected with one line. Instead, the points express a trend. This trend can be calculated mathematically as a regression equation and a correlation value that measures how closely the data follow the general trend.

In an inquiry lab, if the data is numerical, the X (independent) and Y (dependent) variables appear in their usual places on the horizontal and vertical axes, respectively.

Part 4: Analysis and Conclusion

Analysis

The analysis portion of your lab report should describe the data and results in words. You should:

- analyze and state the relationship between the independent and dependent variables by describing how the dependent variable reacted to the change in the independent variable. If you used a control, you should compare the data to the control.
- explain all trends in the data, as well as any significant observations that you made during the lab.
- describe specific data points that help explain the outcome of the experiment.
- present and interpret statistics, such as the range, variance, standard deviation, trend equation, or correlation.
- interpret graphs with descriptions.

Background Research

Before you conduct an experiment, you usually have prior knowledge about the topic that you gained from reliable sources, such as your teacher, books, online resources, or past experiments. You may conduct research before performing an experiment, and sometimes you may do additional research after you complete the experiment but before you write the conclusion of your lab report. Your teacher may provide guidance about the topic you should research, the type and number of sources you should use, when you should do the research, and how that research should appear in your lab report. Your teacher may also ask you to relate the experiment to another topic or discuss it in another context. Be sure to consider all of these things as you write your analysis and conclusion.

Conclusion

The conclusion of your lab report should explain the understandings you've gained as a result of the lab experiment. It should also address the question that led to the experiment. Below is a list of steps you should take when writing your conclusion.

Determine whether the hypothesis was supported. First, restate your hypothesis. A hypothesis is not an answer, so it cannot be described as "correct" or "incorrect." Avoid this common error. Instead, state whether the hypothesis was "supported" or "not supported" by your results. Be sure to explain *how* and *why* you came to that conclusion.

Use the CER (Claim, Evidence, and Reasoning) approach to understand, state, and explain the results of your experiment. A claim is a statement that describes your understanding of the results of your experiment or a scientific phenomenon that you observed. It answers the question: What can you conclude from your experiment? When applicable, the claim describes the relationship between the independent and dependent variable. The evidence is the scientific data (quantitative and/or qualitative) that support the claim. The evidence should be accurate, sufficient, and appropriate. The reasoning connects the claim and evidence. The reasoning describes how and/or why the data is evidence that supports the claim and justifies why the evidence is relevant to the claim made. The reasoning part of your conclusion should include one or more scientific principles that are relevant to the claim and evidence.

Identify possible sources of error. Scientific errors are factors that could have contributed to the uncertainty in the outcome of your experiment. Could measurements have been more accurate? Could you have performed more trials? Could environmental factors, such as the lab's lighting or temperature,

have had an effect? State these possible sources of error and analyze or estimate how much they may have affected your results.

Suggest improvements and further investigation. Even if your hypothesis is not supported by the results of the lab, you can still produce an excellent lab report as long as you show a thorough understanding of the scientific concepts. This is often where your results are linked to your background research. You can now suggest revisions for future experiments based on what you've learned. In this section, you should explain applications of the experiment—how could your findings or those of similar experiments be used in the real world? Lastly, include any related questions you may want to explore in the future.

In an inquiry lab, the **analysis** and **conclusion** will focus on the relationship between X and Y.

Tips for Using Your Student Guide and the Lab Lesson

- The **title** of your lab report should match the title of the lab in the student guide and in the online lesson.
- Your **purpose** statement may be inspired by the purpose statement that appears at the top of the first page of the student guide.
- Your **lab question** and **hypothesis** should be formulated during the lab lesson. If you forgot what you wrote, you can revisit the lesson to copy, paste, and proofread your question and hypothesis.
- The **variables** are generally listed in the header of the student guide.
- The student guide usually provides **tables** for you to use for collecting data. The data table in your lab report can often replicate this format.
- The instruction phase of the lesson usually includes tips from your on-screen teacher for learning how to fill in and interpret the data.
- The student guide may also provide you specific questions to consider as you analyze your results. Be sure to address them in the **analysis and conclusion** of your lab report.

If you are struggling with the lab report, your teacher has access to additional activities that will help you reflect on your lab experience.

Lab Portfolio

You will be required to maintain and submit a Lab Portfolio (hard-copy or electronic) in this course. The Lab Portfolio is a compilation of your lab reports. As part of your Lab Portfolio, you will be asked to write reflection paragraphs about the concepts you applied, the Big Ideas you covered, and the science skills you practiced while performing the laboratory investigations. The Lab Portfolio comprises 20% of your lab grade. Refer to the Lab Portfolio Student Guide to help you build and complete your Lab Portfolio.