Variables

A variable is anything that can affect the quantity being measured. There can be many variables that can affect an experiment. In any fair experiment we try to keep all variables the same (constant) except for one, the one whose effect on the value being measured we want see.
For example in the test to see if temperature affects the bounce of a squash ball the following may affect the bounce.

1. What height we drop the ball from.
2. *The temperature of the ball*
3. The force applied to the ball
4. How or who drops the ball
5. The angle we drop the ball at
6. The surface we drop it on
7. The size, type, shape of the ball

If its to be a fair test all variables except 2 must be kept the same through the experiment, we can do this as follows

1. What height we drop the ball from. – always drop from the same height
2. *The temperature of the ball – we will change this*
3. The force applied to the ball – *just let it fall each time, don't throw*
4. How or who drops the ball – *let the same person drop the ball each time*
5. The angle we drop the ball at – *always let it fall straight down*
6. The surface we drop it on – *always drop it on the same surface*.
7. The size, type, shape of the ball – *always use the same ball.*

Note the Height the ball bounces is also a variable (as it changes with temperature) it is the *variable we measure* – sometimes called the *dependant variable*. The temperature of the ball which is the *variable we change* is sometimes called the *independent variable*.

In some experiments we may also use a control – this is an identical comparison experiment to test our theory. In the comparison we have everything the same except one item, the item whose effect we are testing.

For example if we want to prove that insects produce carbon dioxide we might set up a sealed container with lime water and an insect. The lime water will turn milky white showing that carbon dioxide was produced. To prove that it was indeed the insect that produced the carbon dioxide we could set up an identical experiment but without the insect – this is our control experiment (we say that the insect was the control). If the lime water does not now turn milky it proves that it can only be the insect that was responsible for the carbon dioxide.

Summary

- Variable – anything that change during an experiment and can affect the result of the experiment
- Fixed variable – the variables we keep constant
- Control – a comparison type experiment or item that that is change in such an experiment.

THE FOLLOWING ARE EXTRA NOTES FROM OTHER SOURCES.

Doing a Fair Test: Variables for Beginners

It is important for an experiment to be a **fair test**. You conduct a fair test by making sure that you change one factor at a time while keeping all other conditions the same.

For example, let's imagine that we want to measure which is the fastest toy car to coast down a sloping ramp. If we gently release the first car, but give the second car a push start, did we do a fair test of which car was fastest? No! We gave the second car an unfair advantage by pushing it to start. That's not a fair test! The only thing that should change between the two tests is the car; we should start them down the ramp in exactly the same way.

Let's pretend we're doing an experiment to see if fertilizer makes a plant grow to be larger than a plant that doesn't receive fertilizer. We put seeds of the same kind in three pots with fertilizer and rich soil. But, we run out of soil so we put the seeds without fertilizer in three pots filled with sand. We put all six pots in the same location and water each one with the same amount of water every other day. The plants with soil and fertilizer grow to be much larger than the ones grown in sand without fertilizer. Is that a fair test of whether fertilizer makes a plant grow to be larger? No! We changed two things (type of soil and fertilizer) so we have no idea whether the plants with fertilizer grew to be larger because of the fertilizer or whether the other plants were stunted by being grown in sand. It wasn't a fair test! All of the plants should have been in the same kind of soil.

Conducting a fair test is one of the most important ingredients of doing good, scientifically valuable experiments. To insure that your experiment is a fair test, you must **change only one factor at a time while keeping all other conditions the same**.

Scientists call the changing factors in an experiment **variables**.

Variables

Scientists use an experiment to search for **cause and effect** relationships in nature. In other words, they design an experiment so that changes to one item cause something else to vary in a predictable way.

These changing quantities are called **variables**. A variable is any factor, trait, or condition that can exist in differing amounts or types. An experiment usually has three kinds of variables: independent, dependent, and controlled.

The **independent variable** is the one that is changed by the scientist. To insure a fair test, a good experiment has only one independent variable. As the scientist changes the independent variable, he or she **observes** what happens.

The scientist focuses his or her observations on the **dependent variable** to see how it responds to the change made to the independent variable. The new value of the dependent variable is caused by and depends on the value of the independent variable.

For example, if you open a faucet (the independent variable), the quantity of water flowing (dependent variable) changes in response--you observe that the water flow increases. The number of dependent variables in an experiment varies, but there is often more than one.

Experiments also have **controlled variables**. Controlled variables are quantities that a scientist wants to remain constant, and he must observe them as carefully as the dependent variables. For example, if we want to measure how much water flow increases when we open a faucet, it is important to make sure that the water pressure (the controlled variable) is held constant. That's because both the water pressure and the opening of a faucet have an impact on how much water flows. If we change both of them at the same time, we can't be sure how much of the change in water flow is because of the faucet opening and how much because of the water pressure. In other words, it would not be a fair test. Most experiments have more than one controlled variable. Some people refer to controlled variables as "constant variables."

In a good experiment, the scientist must be able to **measure** the values for each variable. Weight or mass is an example of a variable that is very easy to measure. However, imagine trying to do an experiment where one of the variables is love. There is no such thing as a "love-meter." You might have a **belief** that someone is in love, but you cannot really be sure, and you would probably have friends that don't agree with you. So, love is not measurable in a scientific sense; therefore, it would be a poor variable to use in an experiment.

Examples of Variables

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
How much water flows through a faucet at different openings?	Water faucet opening (closed, half open, fully open)	Amount of water flowing measured in liters per minute	• The Faucet • Water pressure, or how much the water is "pushing" "Different water pressure might also cause different amounts of water to flow and different faucets may behave differently, so to insure a fair test I want to keep the water pressure and the faucet the same for each faucet opening that I test."
Does heating a cup of water allow it to dissolve more sugar?	Temperature of the water measured in degrees Centigrade	Amount of sugar that dissolves completely measured in grams	• Stirring • Type of sugar "More stirring might also increase the amount of sugar that dissolves and different sugars might dissolve in different amounts, so to insure a fair test I want to keep these variables the same for each cup of water."
Does fertilizer make a plant grow bigger?	Amount of fertilizer measured in grams	• Growth of the plant measured by its height • Growth of the plant measured by the number of leaves • See Measuring Plant Growth for more ways to measure plant growth	• Same size pot for each plant • Same type of plant in each pot • Same type and amount of soil in each pot • Same amount of water and light • Make measurements of growth for each plant at the same time "The many variables above can each change how fast a plant grows, so to insure a fair test of the fertilizer, each of them must be kept the same for every pot."
Does an electric motor turn faster if you increase the	Voltage of the electricity measured in volts	Speed of rotation measured in revolutions per minute (RPMs)	• Same motor for every test

voltage?			• The motor should be doing the same work for each test (turning the same wheel, propeller or whatever) "The work that a motor performs has a big impact on its speed, so to insure a fair test I must keep that variable the same."

Time as an Example of an Independent Variable

In some experiments, time is what causes the dependent variable to change. The scientist simply starts the process, then observes and records data at regular intervals.

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
How fast does a candle burn?	Time measured in minutes	Height of candle measured in centimeters at regular intervals of time (for example, every five minutes)	• Use same type of candle for every test • Wind--make sure there is none

The Independent Variable for Surveys and Tests of Different Groups

When a scientist performs a test or survey on different groups of people or things, those groups define the independent variable. For example:

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
Who listens to music the most: teenagers or their parents?	The groups receiving the survey: teenagers or parents	The amount of time that each person listens to music per day measured in hours	Ask the question in exactly the same way to each individual

Either/Or (Binary) Variables

Sometimes a variable simply represents an either/or (binary) condition. For example, something might be either present or not present during an experiment.

Question	Independent Variable (What I change)	Dependent Variables	Controlled Variables

		(What I observe)	(What I keep the same)
Is a classroom noisier when the teacher leaves the room?	Teacher location: The teacher is either in the room or not in the room. "The teacher's location is an either/or situation"	Loudness measured in decibels	• Same classroom • Same students • Same time of day
Do bicycle fenders keep the rider dry when riding through a puddle?	Fenders: The bicycle either has fenders or it does not "Many engineering projects have alternative designs with independent variables like this one (with and without fenders)."	The rider either gets wet or does not "Dependent variables can represent either/or situations, too."	• Same type of bike and tires (except for the fenders!) • Riding at the same speed • Same size and depth of puddle

Science Fair Project Variables Checklist

What Makes for Good Variables?	For Good Variables, You Should Answer "Yes" to Every Question
Is the independent variable measurable?	Yes / No
Can you change the independent variable during the experiment?	Yes / No
Have you identified all relevant dependent variables, and are they all caused by and dependent on the independent variable?	Yes / No
Are all dependent variable(s) measurable?	Yes / No
Have you identified all relevant controlled variables?	Yes / No
Can all controlled variables be held at a steady value during the experiment?	Yes / No

Data Analysis & Graphs

Key Info

- **Review** your data. Try to look at the results of your experiment with a critical eye. Ask yourself these questions:
    - o Is it complete, or did you forget something?
    - o Do you need to collect more data?
    - o Did you make any mistakes?
- **Calculate an average** for the different trials of your experiment, if appropriate.

- **Make sure to clearly label** all tables and graphs. And, include the **units of measurement** (volts, inches, grams, etc.).

- Place your **independent variable on the x-axis** of your graph and the **dependent variable on the y-axis**.

Overview

Take some time to carefully review all of the data you have collected from your experiment. Use charts and graphs to help you analyze the data and patterns. Did you get the results you had expected? What did you find out from your experiment?

Really think about what you have discovered and use your data to help you explain why you think certain things happened.

Calculations and Summarizing Data

Often, you will need to perform calculations on your raw data in order to get the results from which you will generate a conclusion. A spreadsheet program such as Microsoft Excel may be a good way to perform such calculations, and then later the spreadsheet can be used to display the results. Be sure to label the rows and columns--don't forget to include the units of measurement (grams, centimeters, liters, etc.).

You should have performed multiple trials of your experiment. Think about the best way to summarize your data. Do you want to calculate the average for each group of trials, or summarize the results in some other way such as ratios, percentages, or error and significance for really advanced students? Or, is it better to display your data as individual data points?

Do any calculations that are necessary for you to analyze and understand the data from your experiment.

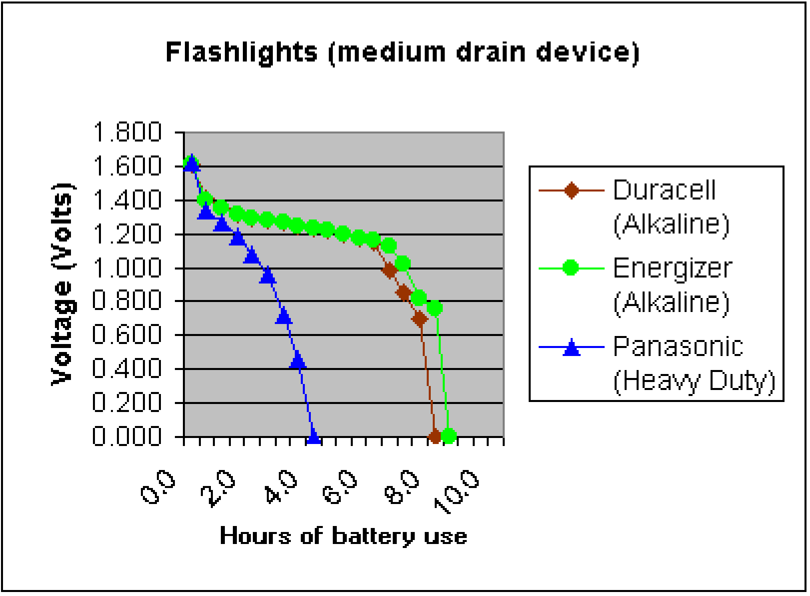
- Use calculations from known formulas that describe the relationships you are testing. (F = MA , V = IR or E = MC2)
- Pay careful attention because you may need to convert some of your units to do your calculation correctly. All of the units for a measurement should be of the same scale– (keep L with L and mL with mL, do not mix L with mL!)

Graphs

Graphs are often an excellent way to display your results. In fact, most good science fair projects have at least one graph.

For any type of graph:

- Generally, you should place your independent variable on the x-axis of your graph and the dependent variable on the y-axis.
- Be sure to label the axes of your graph— don't forget to include the units of measurement (grams, centimeters, liters, etc.).
- If you have more than one set of data, show each series in a different color or symbol and include a legend with clear labels.



Different types of graphs are appropriate for different experiments. These are just a few of the possible types of graphs:

A **bar graph** might be appropriate for comparing different trials or different experimental groups. It also may be a good choice if your independent variable is not numerical. (In Microsoft Excel, generate bar graphs by choosing chart types "Column" or "Bar.")

A **time-series** plot can be used if your dependent variable is numerical and your independent variable is time. (In Microsoft Excel, the "line graph" chart type generates a time series. By default, Excel simply puts a count on the x-axis. To generate a time series plot with your choice of x-axis units, make a separate data column that contains those units next to your dependent variable. Then choose the "XY (scatter)" chart type, with a sub-type that draws a line.)

An **xy-line graph** shows the relationship between your dependent and independent variables when both are numerical and the dependent variable is a function of the independent variable. (In Microsoft Excel, choose the "XY (scatter)" chart type, and then choose a sub-type that does draw a line.)

A **scatter plot** might be the proper graph if you're trying to show how two variables may be related to one another. (In Microsoft Excel, choose the "XY (scatter)" chart type, and then choose a sub-type that does not draw a line.)

Sample

Here is a sample Excel spreadsheet that contains data analysis and a graph.

Data Analysis Checklist

What Makes for a Good Data Analysis Chart?	For a Good Chart, You Should Answer "Yes" to Every Question
Is there sufficient data to know whether your hypothesis is correct?	Yes / No
Is your data accurate?	Yes / No
Have you summarized your data with an average, if appropriate?	Yes / No
Does your chart specify units of measurement for all data?	Yes / No
Have you verified that all calculations (if any) are correct?	Yes / No

Graph Checklist

What Makes for a Good Graph?	For a Good Graph, You Should Answer "Yes" to Every Question

Have you selected the appropriate graph type for the data you are displaying?	Yes / No
Does your graph have a title?	Yes / No
Have you placed the independent variable on the x-axis and the dependent variable on the y-axis?	Yes / No
Have you labeled the axes correctly and specified the units of measurement?	Yes / No
Does your graph have the proper scale (the appropriate high and low values on the axes)?	Yes / No
Is your data plotted correctly and clearly?	Yes / No