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The Scientific Method

Scientific Method Steps

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Introduction to the Scientific Method

Okay, you need to come up with a scientific research project or science fair project. One of the obvious challenges is to find an idea for the project. Also, you need *science* involved, so you will need to apply the scientific method somehow. The scientific method can be stated several ways, but basically it involves looking at the world around you, coming up with an explanation for what you observe, testing your explanation to see if it could be valid, and then either accepting your explanation (for the time being... after all, something better might come along!) or rejecting the explanation and trying to come up with a better one. If you are having trouble designing an experiment or even getting an idea for a project, start with the first step of the scientific method: make observations.

Scientific Method Step 1: Make Observations

A lot of people think that the scientific method starts with forming a hypothesis. The reason for this misconception may be because many observations are made informally. After all, when you are looking for a project idea, you think through all of the things you have experienced (observations you have made) and try to find one that would be suitable for an experiment. Although the informal variation of Step 1 works, you will have a richer source of ideas if you pick a subject and write down observations until a test-able idea comes up. For example, let's say you want to do an experiment, but you need an idea. Take what is around you and start writing down observations. Write down everything! Include colors, timing, sounds, temperatures, light levels... you get the idea.

Scientific Method Step 2: Formulate a Hypothesis

A hypothesis is a statement that can be used to predict the outcome of future observations. The *null hypothesis*[1], or no-difference hypothesis, is a good type of hypothesis to test. This type of hypothesis assumes no difference between two states. Here is an example of a null hypothesis: 'the rate at which grass grows is not dependent on the amount of light it receives'. Even if I think that light affects the rate at which my grass grows (probably not as much as rain, but that's a different hypothesis), it is easier to disprove that light has no effect than to get into complicated details about 'how much light', or 'wavelength of light', etc. However, these details can become their own hypotheses (stated in null form) for further experimentation. It is easiest to test separate variables in separate experiments. In other words, don't test the effects of light and water at the same time until after you have tested each separately.

Scientific Method Step 3: Design an Experiment

There are many different ways to test a single hypothesis. If I wanted to test the null hypothesis, 'the rate of grass growth is not dependent on quantity of light', I would have grass exposed to no light (a control group... identical in every way to the other experimental groups except for the variable being tested), and grass with light. I could complicate the experiment by having differing levels of light, different types of grasses, etc. Let me stress that the control group can only differ from any experimental groups with respect to the *one* variable. For example, in all fairness I could not compare grass in my yard in the shade and grass in the sun... there are other variables between the two groups besides light, such as moisture and probably pH of the soil (where I am it is more acidic near the trees and buildings, which is also where it is shady). Keep your experiment simple.

Scientific Method Step 4: Test the Hypothesis

In other words, perform an experiment! Your data might take the form of numbers, yes/no, present/absent, or other observations. It is important to keep data that 'looks bad'. Many experiments have been sabotaged by researchers throwing out data that didn't agree with preconceptions. Keep all of the data! You can make notes if something exceptional occurred when a particular data point was taken. Also, it is a good idea to write down observations related to your experiment that aren't directly related to the hypothesis. These observations could include variables over which you have no control, such as humidity, temperature, vibrations, etc., or any noteworthy happenings.

Step 5: Accept or Reject the Hypothesis

For many experiments, conclusions are formed based on informal analysis of the data. Simply asking, 'Does the data fit the hypothesis', is one way to accept or reject a hypothesis. However, it is better to apply a statistical analysis to data, to establish a degree of 'acceptance' or 'rejection'. Mathematics is also useful in assessing the effects of measurement errors and other uncertainties in an experiment.

Hypothesis Accepted? Things to Keep in Mind

Accepting a hypothesis does not guarantee that it is the correct hypothesis! This only means that the results of your experiment support the hypothesis. It is still possible to duplicate the experiment and get different results next time. It is also possible to have a hypothesis that explains the observations, yet is the incorrect explanation. Remember, a hypothesis can be disproven, but never proven!

Hypothesis Rejected? Back to Step 2

If the null hypothesis was rejected, that may be as far as your experiment needs to go. If any other hypothesis was rejected, then it is time to reconsider your explanation for your observations. At least you won't be starting from scratch... you have more observations and data than ever before!

Links in this article:

1. http://chemistry.about.com/od/chemistryglossary/g/Null-Hypothesis-Definition.htm