Scientific Method

The series of steps that scientists use to answer questions and solve problems is often called the scientific method. The scientific method is not a rigid procedure. Scientists may use all of the steps or just some of the steps of the scientific method. They may even repeat some of the steps. The goal of the scientific method is to come up with reliable answers and solutions.

Six Steps of the Scientific Method

1. Ask a Question  
   Good questions come from careful observations. You make observations by using your senses to gather information. Sometimes you may use instruments, such as microscopes and telescopes, to extend the range of your senses. As you observe the natural world, you will discover that you have many more questions than answers. These questions drive the scientific method.

   Questions beginning with what, why, how, and when are very important in focusing an investigation, and they often lead to a hypothesis. (You will learn what a hypothesis is in the next step.) Here is an example of a question that could lead to further investigation.

   **Question:** How does acid rain affect plant growth?

2. Form a Hypothesis  
   After you come up with a question, you need to turn the question into a hypothesis. A hypothesis is a clear statement of what you expect the answer to your question to be. Your hypothesis will represent your best “educated guess” based on your observations and what you already know. A good hypothesis is testable. If observations and information cannot be gathered or if an experiment cannot be designed to test your hypothesis, it is untestable, and the investigation can go no further.

   Here is a hypothesis that could be formed from the question, “How does acid rain affect plant growth?”

   **Hypothesis:** Acid rain causes plants to grow more slowly.

   Notice that the hypothesis provides some specifics that lead to methods of testing. The hypothesis can also lead to predictions. A prediction is what you think will be the outcome of your experiment or data collection. Predictions are usually stated in an “if . . . then” format. For example, if meat is kept at room temperature, then it will spoil faster than meat kept in the refrigerator. More than one prediction can be made for a single hypothesis. Here is a sample prediction for the hypothesis that acid rain causes plants to grow more slowly.

   **Prediction:** If a plant is watered with only acid rain (which has a pH of 4), then the plant will grow at half its normal rate.
3 **Test the Hypothesis** After you have formed a hypothesis and made a prediction, you should test your hypothesis. There are different ways to do this. Perhaps the most familiar way is to conduct a **controlled experiment**. A controlled experiment tests only one factor at a time. A controlled experiment has a **control group** and one or more **experimental groups**. All the factors for the control and experimental groups are the same except for one factor, which is called the **variable**. By changing only one factor, you can see the results of just that one change.

Sometimes, the nature of an investigation makes a controlled experiment impossible. For example, dinosaurs have been extinct for millions of years, and the Earth's core is surrounded by thousands of meters of rock. It would be difficult, if not impossible, to conduct controlled experiments on such things. Under such circumstances, a hypothesis may be tested by making detailed observations. Taking measurements is one way of making observations.

4 **Analyze the Results** After you have completed your experiments, made your observations, and collected your data, you must analyze all the information you have gathered. Tables and graphs are often used in this step to organize the data.

5 **Draw Conclusions** Based on the analysis of your data, you should conclude whether or not your results support your hypothesis. If your hypothesis is supported, you (or others) might want to repeat the observations or experiments to verify your results. If your hypothesis is not supported by the data, you may have to check your procedure for errors. You may even have to reject your hypothesis and make a new one. If you cannot draw a conclusion from your results, you may have to try the investigation again or carry out further observations or experiments.

6 **Communicate Results** After any scientific investigation, you should report your results. By doing a written or oral report, you let others know what you have learned. They may want to repeat your investigation to see if they get the same results. Your report may even lead to another question, which in turn may lead to another investigation.
Scientific Method in Action

The scientific method is not a “straight line” of steps. It contains loops in which several steps may be repeated over and over again, while others may not be necessary. For example, sometimes scientists will find that testing one hypothesis raises new questions and new hypotheses to be tested. And sometimes, testing the hypothesis leads directly to a conclusion. Furthermore, the steps in the scientific method are not always used in the same order. Follow the steps in the diagram below, and see how many different directions the scientific method can take you.