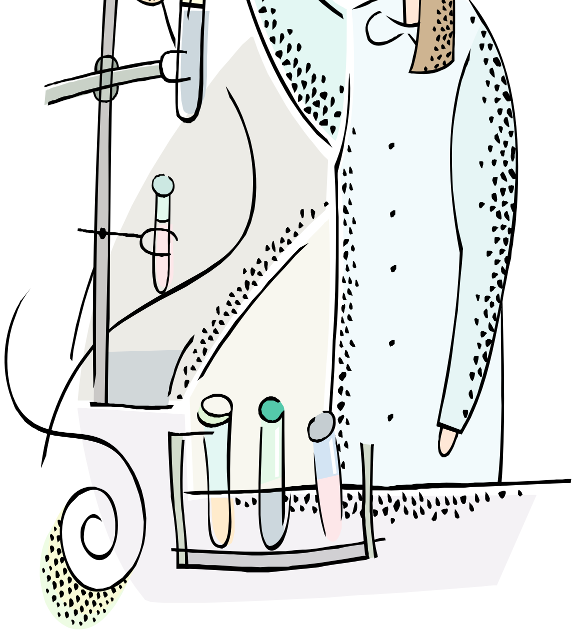


THE SCIENTIFIC METHOD

Suppose you are upstairs in your house when you hear a crash and clanging sound from downstairs. You run downstairs and see your little brother crying on the floor next to an overturned chair and two pans. The cupboard door above him where the pots, pans, and leftover Halloween candy is kept, is wide open.

The details in the paragraph above describe your observations. For example, you heard a crash, you observed the overturned chair, and you actually saw your brother on the floor crying.

You can reasonably conclude that your little brother got up onto a chair to get some candy, and that he fell, knocking some pans out of the cupboard and the chair over. These are your inferences.

Although you did not actually observe your brother fall off the chair, the position of the chair and your brother on the floor leads you to think that he did fall. And although you didn't know that your brother wanted the candy, the open cupboard door, and the pans from the same cupboard where the candy is kept lead you to think that he did. Scientists make inferences from their observations in much the same way.

Scientifically minded people generally believe in cause-and-effect relationships. They feel there is a perfectly natural explanation for most things. For example, there is a reason why milk sours and why some leaves turn red in the fall, while others turn yellow. Changes such as these, which are easily observed, are known as phenomena. Some common phenomena are not completely understood. Still others cannot be explained at all at this time. The belief that effects have causes plays a significant part in the scientific method. The cause of AIDS, for example, was once unknown. Nevertheless, scientists firmly believed that a cause existed. Once they discovered that it was caused by a virus, scientists could search for a remedy. If everyone believed that a disease just happened without a natural cause, no progress would be made in learning to control it.

Scientists spend tremendous amounts of time making observations and gathering information, or data. They work using the ***scientific method***. Overall, the scientific method involves four basic steps. There are variations in some scientific methods which may breakdown one or more of these steps into more detailed steps. The four basic steps involve **OBSERVATION, HYPOTHESIS, EXPERIMENT, and CONCLUSION**.

OBSERVATION

The observation step begins with a **problem**. Scientists can become interested in a particular problem from reading about it or simply by observing something in nature. They ask questions that begin with "Why does…?", "How does…?", or "What determines…?" When the term **"observation"** is used, concerning the scientific method, it is defined as the process of using any of your five senses to gain information about your environment or about a problem. As soon as the observations are made, inferences are then made. An **inference** is defined as drawing conclusions on the basis of facts. In other words, an inference is essentially a guess based on facts or observations that were made. Once the problem is firmly grasped, the scientist tries to learn as much as possible about it. Frequently this involves studying books and journals that contain information about the problem. This is called searching the literature.

HYPOTHESIS

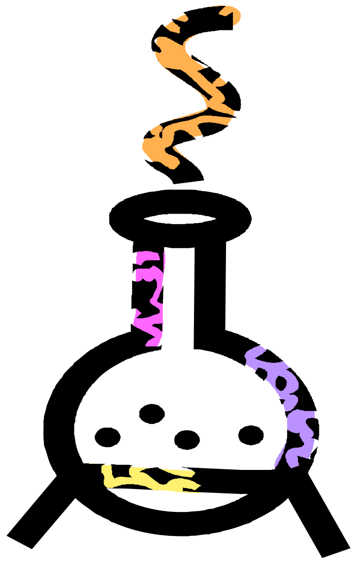
Once the problem has been identified, observations have been made, and research has been completed to learn of the problem, the scientist then moves to the second overall step, HYPOTHESIS.

A hypothesis is defined many ways. Some describe it as an educated guess or a testable statement. A **hypothesis** can best be defined as a possible explanation of some event or idea that can be tested or experimented. A hypothesis is a statement, not a question, that may be a correct explanation of some event or idea, or it may not. Performing the third step of the scientific method, conducting an experiment, will prove the hypothesis correct or incorrect.

EXPERIMENT

After a hypothesis is created the scientist then designs an experiment to test and see if their educated guess or testable statement is correct. An **experiment** can be defined as a procedure that is designed and carried out under controlled conditions to prove or disprove a hypothesis. Keep in mind that most controlled experiments are performed in laboratories, and that not all experiments are controlled. When a biologist is doing field work, the experiment cannot be completely controlled. There are many scientific questions that are not able to be tested by scientific methods. Just because they are not able to be answered does not mean that these questions are unimportant. Some questions just cannot be tested scientifically in a controlled experiment that would yield valid data.

An experiment will consists of a control group, experimental group, constants, dependent variable and independent variable. The **control group** is used as a standard of comparison in which everything is kept as natural or normal as possible. The **experimental group** is constant or consistent with the control group except that one item is changed within it. **Constants** are all of the items that remain the same among the control and experimental groups. The **independent variable**, which is also described as the manipulated variable or testing variable, is the one item that is changed between the two groups. The independent variable is found in the experimental group but not the control group. The **dependent variable** is the responding variable which is measured. The experiment gives the scientist measurements and observations, referred to as data, which can be described as qualitative or quantitative. **Quantitative data** is defined as data recorded as numbers. This type of data often is used to make graphs and tables that communicate large amounts of information in an easy to understand format. **Qualitative data** is data recorded as descriptions or words. An example of qualitative research could be comparing the attitudes of people who live in cloudy regions with people who live in a sunnier climate.



CONCLUSION

The experiment gives the scientist measurements and observations, which are then analyzed. Analyzing the data brings you to the final step of the scientific method which is conclusion. **Conclusion** is defined as a statement that tells if the data supports the hypothesis or not. After the data is analyzed, a conclusion can be made as to whether the hypothesis was correct or incorrect. If the hypothesis was incorrect based on the data, the scientist can return back to step two, revise the hypothesis, and test it again. If the hypothesis was correct, scientists in other laboratories repeat the experiment to make sure that they get the same results. Scientific results must be repeatable. This means that scientists must get the same results every time they do the same experiment. If the results of the other scientists' tests are the same, the scientific community will accept the hypothesis. The hypothesis then becomes a theory—an explanation for why something happens. Theories can be revised if scientists discover new information about the subject.

The Five Steps of the Scientific Method (04:42)

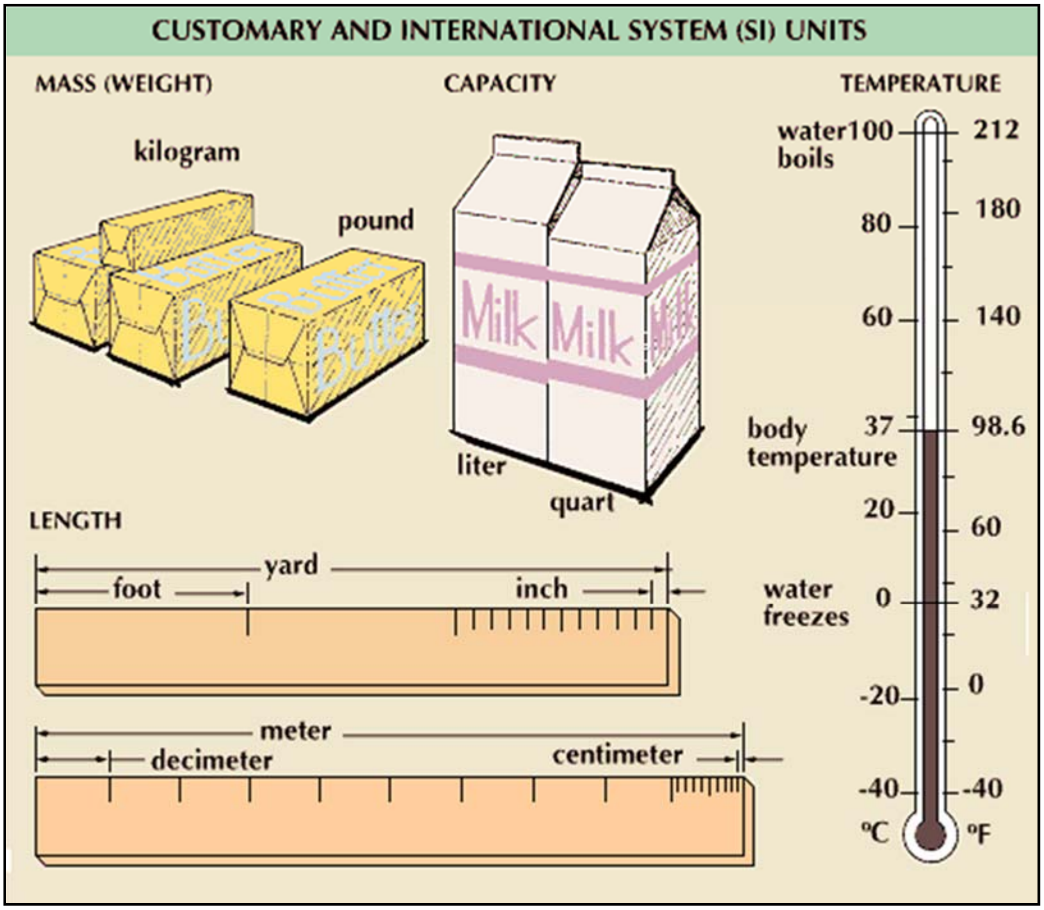
SCIENTIFIC METHOD EXAMPLE

Example scenario:

An experiment was designed to investigate the effect of caffeine on the heartbeat of water fleas. Two populations of water fleas were cultured. Both populations had water with the ***same mineral content****, were supplied with* ***identical amounts of bacteria as food****, received the* ***same amount of light****, and had* ***their temperature maintained*** *at 20 degrees Celsius. Every two hours, water fleas from both populations were selected and their* ***heartbeats were monitored****. The fleas from* ***population one****, however, had* ***caffeine*** *administered 5 minutes before the heartbeat was checked while* ***population two*** *was given nothing.*

Questions about the "Experiment Details" for the above example	Answers
What is the Control Group? *(Group kept as the standard or normal situation.)*	**Population 2**
What is the Experimental Group? *(Group that has one item different from the control group.)*	**Population 1**
What is the Independent Variable? *(The item that is added to the experimental group but not to the control group.)*	**Caffeine**
What is the Dependent Variable? *(The responding, or measuring, item or variable.)*	**Heartbeat of the water fleas**
What are the Constants? *(All items that are kept the same between the control and experimental groups.)*	**Food, water temperature, mineral content, and light**

International System of Measurement (SI system)



Biologists all over the world use the **International System of Measurement (SI system)** to report quantitative information about their experiments. This SI system has an advantage over using the English system that most of us in the United States use. One advantage is that, it is like the metric system, a decimal system with measurements is found in multiples of tens or tenths of a basic unit by using a set of prefixes. Therefore, it is easier to convert from one measurement to another.

The following video briefly examines the disparity between the U.S. customary and metric systems, explaining who uses the metric system and why and teaching the value of knowing how to convert between the two. This program demonstrates two methods of unit conversions, the unit cancellation and moving decimal formulas. Practice conversion problems reinforce these new strategies while introducing two new metric unit measurements, fluid volume in liters and mass in grams.

Measurement: The Metric System

Scientific Method Worksheet

Now answer questions 1 through 25.