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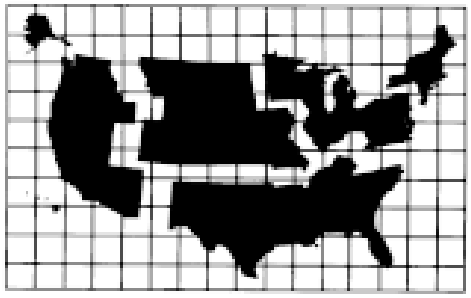

ENVIRONMENTAL SCIENCE AND TECHNOLOGY BRIEFS FOR CITIZENS

by W.M. Griswold

Science Basics

Exploring the fundamentals of science

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Science. The word itself is intimidating to many people. The principles of science are used to understand and deal with environmental problems. This document is intended to provide a basic understanding of the scientific method and an introduction to technical reports.

Scientific Method

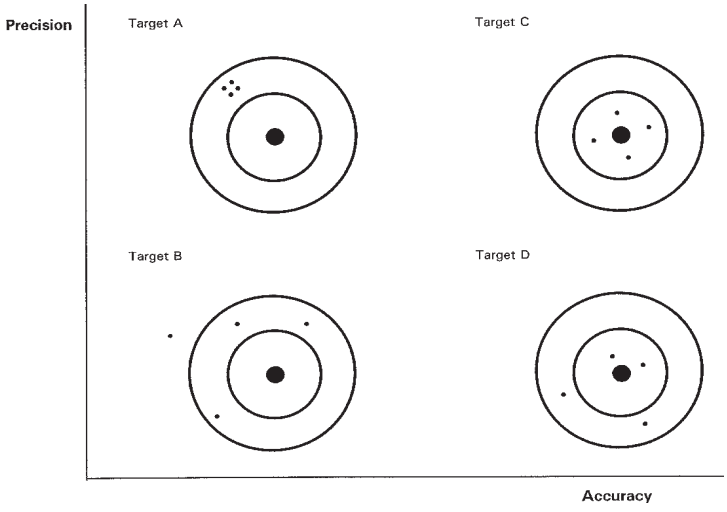
By definition, science is the observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena. Like many areas of our lives, the field of science is bound by rules and regulations regarding its application and use. The scientific method refers to the principles and processes regarded as necessary for scientific investigation. This includes rules for concept formation, conducting observations and experiments, and validation of hypotheses by observations and experiments. Four steps are involved in the scientific method:

- observation
- deduction
- hypothesis
- testing

Observation

If a person wanted to examine an event or phenomenon using the scientific method, one would begin by making an observation. An observation is the act of noting and recording an event. Making an observation can be as simple as seeing something with your eyes and making a note of it or measuring the clarity of water with a turbidity meter. Scientists often make quantitative observations. These are observations that obtain measurements from the analyis of samples. Accuracy and precision of measurements are fundamentals of quantitative observation. Accuracy is how close measurements are to the true or actual value. A high level of precision indicates consistent measurement techniques. Figure one illustrates the relationship between accuracy and precision. Target A represents a series of events that are precise in relation to each other, but not accurate, as they are not near the bullseye. The events in target B are neither accurate nor precise. There is a wide range in the relationship of the events to one another and none of them is near the bullseye. Target D is more accurate than precise.

Figure 1. The relationship between precision and accuracy



There is not a clear relationship in the events to one another, but many of them are nearer to the bullseye than the events in targets A or B. The events in target C are the most accurate and precise of all of the targets.

Deduction

After making observations, the next step is to make a deduction. A deduction is the process of reasoning that leads to a possible conclusion based on observations, physical laws, and well-established theories. It is an inference by reasoning from the general to the specific.

Hypothesis

Once a deduction has been made, the scientist uses that deduction to form a hypothesis. A hypothesis or theory is an explanation accounting for a set of facts and can be tested by further investigation. A good hypothesis

- is as simple as possible
- takes all known facts into account
- can be tested
- can't be proven negative

Testing

Next, the hypothesis is tested. A test is any well-defined experiment that can be used to confirm or deny the stated hypothesis. Often this is expressed as a statistical test of measured variables. A good experiment should be able to confirm or reject a hypothesis. Test results are often inconclusive, which means that more information needs to be collected or a new test needs to be conducted. In the testing, or experimentation, phase of the scientific method, the concept of repeatability is important. If an experiment can be repeated with the same results, especially if conducted by different scientists, it lends credence to the reliability or correctness of the hypothesis being tested.

The scientific method can be used to examine many types of natural phenomenon. The scientific method is used not only in the laboratory, but in the daily lives of humans. For example, Sally observes a damp spot on her living room ceiling and standing water on the floor. From these observations, Sally deduces that water is entering her home from the outside. She develops this deduction into the hypothesis that there is a hole in her roof. Sally tests her hypothesis by simulating rainfall on the roof. She places a bucket where she found the standing water. Next, Sally hoses down the area of the roof that covers the living room. After simulating the rainfall, Sally returns to the site of her initial observation. There is water in the bucket, dripping from the ceiling. There is evidence to support her hypothesis.

Reading Technical Reports

Often the size and language of technical reports can be intimidating to people not trained in their use and construction. You may find technical reports more approachable by identifying the different sections before beginning to read.

Technical reports are written documentation of researchers' use of the scientific method. Technical reports can vary in length and scope, but the format is essentially standard. They are broken down into several different sections: abstract or executive summary, introduction, methodology or procedures, results, and conclusions or recommendations. Many reports are also accompanied by appendices which contain additional information usually referred to in the body of the report.

The abstract or executive summary contains a brief description of the technical report. It essentially tells the reader what the report is about as concisely as possible.

The introduction is a longer and more detailed version of the executive summary. The introduction should tell the reader the purpose of the report and give a summary of what is to follow.

The methods or procedures section will detail how the data discussed in the report was collected and analyzed. This may include methods for collecting samples, equipment and tests used, and quality control information. The results section will report the outcome of any tests or measurements that were conducted.

The conclusion or recommendations section will summarize the report. This section may also draw conclusions, make recommendations based on the research results, or suggest other hypotheses that should be tested.

Many technical reports contain appendices following the main body of the report. Frequently, material contained in the appendices provides a more in-depth view of the data being discussed in the body of the report. The key to understanding this type of material is a basic understanding of mathematics and statistics.

Conclusion

As this example shows, the scientific method is a way that people can investigate a situation and draw conclusions about that situation. Scientists are very careful about using the scientific method and documenting the method because it helps them to evaluate complex problems and develop solutions.

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ABOUT THE AUTHOR: Wendy Griswold has a B.A. from the University of Kansas and an M.S. from Mankato State University in Women's Studies. She currently works for the GP/RM HSRC.