Scientific Method

The **scientific method** *is a logical approach to solving problems by observing and collecting data, formulating hypotheses, testing hypotheses, and formulation theories that are supported by data*.

Observing and Collecting Data

Observing is the use of the senses to obtain information. Observation often involves making measurements and collecting data. The data may be descriptive (qualitative) or numerical (quantitative) in nature. Numerical information, such as the fact that a sample of copper ore has a mass of 25.7, is *quantitative*. Non-numerical information, such as the fact that the sky is blue, is *qualitative*. Chemists study systems to learn more about matter. *A* **system** *is a specific portion of matter in a given region of space that has been selected for study during an experiment or observation*. When you observe a reaction in a test tube, the test tube and its contents form a system.

Formulating Hypotheses

As scientists examine and compare the data from their own experiments, they attempt to find relationships and patterns---in other words, they make generalizations based on the data. Generalizations are statements that apply to a range of information. To make generalizations, data are sometimes organized in tables and analyzed using statistics or other mathematical techniques. Scientists use generalizations about the data to formulate a **hypothesis**, *or testable statement*. The hypothesis serves as a basis for making predictions and for carrying out further experiments. Hypotheses are often drafted as "if-then" statements. The "then" part of the hypothesis is a prediction that is the basis for testing by experiment.

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Testing Hypotheses

Testing a hypothesis requires experimentation that provides data to support or refute a hypothesis or theory. During testing, the experimental conditions that remain constant are called *controls*, and any condition that changes is called a *variable*. Any change observed is usually due to the effects of the variable. IF testing reveals that the predictions were not correct, the hypothesis on which the predictions were based must be discarded or modified.

Theorizing

When the data from experiments show that the predictions of the hypothesis are successful, scientists typically try to explain the phenomena they are studying by constructing a model. *A* **model** *in science is more than a physical object it is often an explanation of how phenomena occur and how data or events are related*. Models may be visual, verbal, or mathematical. One important model in chemistry is the atomic model of matter, which states that matter is composed of tiny particles called atoms. If a model successfully explains many phenomena, it may become part of a theory. The atomic model is a part of the atomic theory. *A* **theory** *is a broad generalization that explains a body of facts or phenomena*. Theories are considered successful if they can predict the results of many new experiments.