Scientific Explanations

Questions that scientists seek to answer and problems that they hope to solve often come after they observe something. These observations can be made of the natural world or in a laboratory. A scientist must always make careful observations, avoiding bias during an experiment or data analysis. In fact, scientists that make up a research group should realize that they probably think alike and seek out any bias during their experiments.

Once observations have been made, they must be analyzed. Scientists start by looking at all the relevant information or data they have gathered. They look for patterns that might suggest an explanation for the observations. This proposed explanation is called a **hypothesis.** A hypothesis is a reasonable and testable explanation for observations.

hypothesis
a theory or explanation that is based on observations and that can be tested

Chemists Use Experiments to Test a Hypothesis

Once a scientist has developed a hypothesis, the next step is to test the validity of the hypothesis. This testing is often done by carrying out experiments, as shown in **Figure 11.** Even though the results of their experiments were totally unexpected, Plunkett and Perkin developed hypotheses to account for their observations. Both scientists hypothesized that their accidental discoveries might have some practical application. Their next step was to design experiments to test their hypotheses.

To understand what is involved in designing an experiment, consider this example. Imagine that you have observed that your family car has recently been getting better mileage. Perhaps you suggest to your family that their decision to use a new brand of gasoline is the factor responsible for the improved mileage. In effect, you have proposed a hypothesis to explain an observation.

Figure 11
Students conduct experiments to test the validity of their hypotheses.

Figure 13
In 1974, scientists proposed a theory to explain the observation of a hole in the ozone layer over Antarctica, which is shown in purple. This hole is about the size of North America.

Data from Experiments Can Lead to a Theory

As early as 1969, scientists observed that the ozone layer was breaking down. Ozone, O_3, is a gas that forms a thin layer high above Earth's surface. This layer shields all living things from most of the sun's damaging ultraviolet light. In 1970, Paul Crutzen, working at the Max Planck Institute for Chemistry, showed the connection between nitrogen oxides and the reduction of ozone in air. In 1974, F. Sherwood Rowland and Mario Molina, two chemists working at the University of California, Irvine, proposed the hypothesis that the release of chlorofluorocarbons (CFCs) into the atmosphere harms the ozone layer. CFCs were being used in refrigerators, air conditioners, aerosol spray containers, and many other consumer products.

Repeated testing has supported the hypothesis proposed by Rowland and Molina. Any hypothesis that withstands repeated testing may become part of a **theory.** In science, a theory is a well-tested explanation of observations. (This is different from common use of the term, which means "a guess.") Because theories are explanations, not facts, they can be disproved but can never be completely proven. In 1995, Crutzen, Rowland, and Molina were awarded the Nobel Prize in chemistry in recognition of their theory of the formation and decomposition of the ozone layer.

theory
an explanation for some phenomenon that is based on observation, experimentation, and reasoning

Theories and Laws Have Different Purposes

Some facts in science hold true consistently. Such facts are known as laws. A **law** is a statement or mathematical expression that reliably describes a behavior of the natural world. While a theory is an attempt to explain the cause of certain events in the natural world, a scientific law describes the events.

For example, the **law of conservation of mass** states that the products of a chemical reaction have the same mass as the reactants have. This law does not explain why matter in chemical reactions behaves this way; the law simply describes this behavior. In some cases, scientific laws may be reinterpreted as new information is obtained. Keep in mind that a hypothesis *predicts* an event, a theory *explains* it, and a law *describes* it.

law
a summary of many experimental results and observations; a law tells how things work

law of conservation of mass
the law that states that mass cannot be created or destroyed in ordinary chemical and physical changes