Walch Science Literacy Series
Chemistry

by David E. Newton

illustrated by Carol Stutz

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Lesson 7

Tracking Down the Cause

Does smoking cause lung cancer? That question has been one of the most widely discussed health issues in the second half of the twentieth century in the United States. Cigarette smoking, once less common, rapidly gained popularity in the 1930's and 1940's. Eventually, two out of every five Americans were counted as smokers.

Some health experts became concerned about this trend. They began to see a rise in the number of respiratory diseases, such as chronic bronchitis, emphysema, and lung cancer. They suspected that cigarette smoking might be the cause of this rise.

Cigarette manufacturers disagreed. They could not deny the increase in cases of respiratory diseases. But this increase was not caused by cigarette smoking, they argued. It was only a coincidence that respiratory diseases and cigarette smoking increased at the same time.

This story illustrates the problem that scientists have in separating **cause-and-effect** relationships from **correlational** relationships. A cause-and-effect relationship is one in which it is possible to say that factor A *causes* event B to take place. Health workers were saying that cigarette smoking caused respiratory disease.

A correlational relationship is one in which two **variables** change according to a similar pattern. But there may or may not be a cause-and-effect relationship between the two. To pick an absurd example, if you graphed the number of Protestant ministers coming to the United States from 1650 to 1750 and the number of cases of rum imported during the same period, a result like the one in Figure 7.1 might be obtained. There is obviously a correlational relationship here. But is there also a cause-and-effect relationship? If so, what is it?

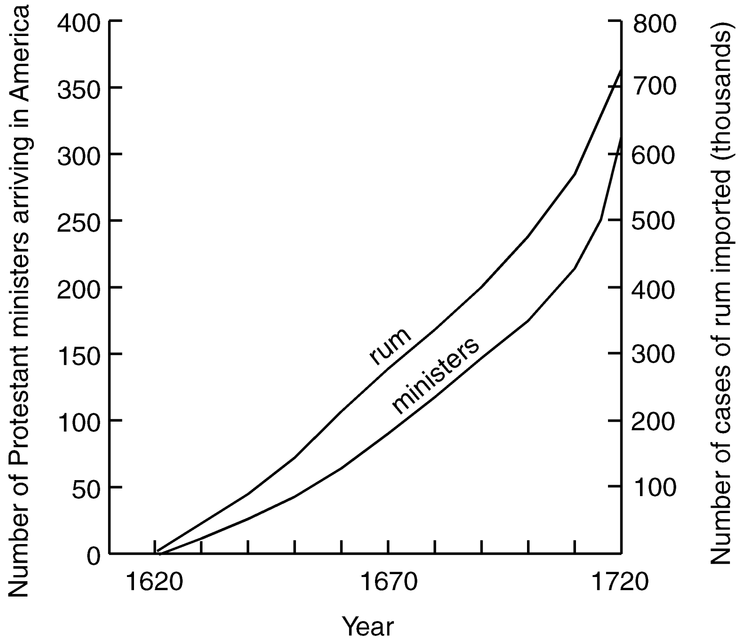

Figure 7.1

1. State in words the correlational relationship shown by the graph.

2. State two possible cause-and-effect relationships that could account for the data shown by the graph.

3. What does the term *variable* mean in mathematics and science?

4. Can you find four variables mentioned in the information in the text?

Lesson 18

The Search for Quarks

Value of Basic Research

Scientists never seem to know when to stop. They do experiments to find the answer to some question, often with success. But in most cases, the answer they find suggests new questions which, in turn, require new experiments. This process often goes on over and over again.

Consider the question: What is the smallest particle of matter? In the 1800's, chemists thought the answer to that question was the **atom.** But in the 1890's, scientists discovered **electrons** inside an atom. Then they knew that the atom itself was composed of smaller particles. Later they learned that atoms also contain **protons** and **neutrons.**

So protons, neutrons, and electrons are the smallest particles of matter, right? It seems not. In the 1950's, scientists began to suspect that protons and neutrons themselves (but not electrons) consist of even smaller particles, to which they gave the name **quarks.** The search has become somewhat like opening a Chinese puzzle box, with each box containing yet a smaller box.

Today, scientists have discovered five (and probably six) kinds of quarks that they believe make up all kinds of matter. Quarks are used to build protons and neutrons which, in turn, are used to build atoms. In addition, scientists have found six kinds of **leptons,** of which the electron is one. These six quarks and six leptons are now thought to be the smallest particles of which matter is made.

Discovering quarks and leptons has required one of the largest and most expensive research programs ever developed. These particles can be produced only in very large **particle accelerators** (atom smashers) that cost millions and even billions of dollars. Hundreds of scientists are involved in each study on fundamental particles.

Is the information gained worth all that time, money, and effort? After all, knowing about fundamental particles may be an exciting **basic research** project and will surely add to the world's storehouse of knowledge. But it won't help solve crucial social problems, such as feeding the hungry or housing the homeless.

Besides, quark hunting is so expensive that it can normally be financed only by national governments. How do *you* feel about spending your tax dollars on that kind of research? Would you be willing to pay $1 a year, $10 a year, $100 a year so that scientists could find out more about quarks, to see if quarks themselves may be made of even smaller particles?

Use reference sources such as library books and magazines or the Internet to find information to help you answer the following questions.

1. Make a simple diagram showing where protons, neutrons, and electrons are found in an atom.

2. What does it mean to say that an atom is *smashed* when it is placed inside a particle accelerator, or atom smasher?

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3. Hypothesize a reason that particle accelerators can also tell about the composition of protons and neutrons.

4. Quark hunting is an example of basic research. Basic research is not conducted to solve any specific practical problem. Why, then, is it done?