

## 1.2 Scientists form generalizations from observations.

### The Nature of Science

Biology is a fascinating and important subject, because it dramatically affects our daily lives and our futures. Many biologists are working on problems that critically affect our lives, such as the world's rapidly expanding population and diseases like cancer and AIDS. The knowledge these biologists gain will be fundamental to our ability to manage the world's resources in a suitable manner, to prevent or cure diseases, and to improve the quality of our lives and those of our children and grandchildren.

Biology is one of the most successful of the “natural sciences,” explaining what our world is like. To understand biology, you must first understand the nature of science. The basic tool a scientist uses is thought. To understand the nature of science, it is useful to focus for a moment on how scientists think. They reason in two ways: deductively and inductively.

### Deductive Reasoning

**Deductive reasoning** applies general principles to predict specific results. Over 2200 years ago, the Greek Eratosthenes used deductive reasoning to accurately estimate the circumference of the earth. At high noon on the longest day of the year, when the sun's rays hit the bottom of a deep well in the city of Syene, Egypt, Eratosthenes measured the length of the shadow cast by a tall obelisk in Alexandria, about 800 kilometers to the north. Because he knew the distance between the two cities and the height of the obelisk, he was able to employ the principles of Euclidean geometry to correctly deduce the circumference of the earth (figure 1.3). This sort of analysis of specific cases using general principles is an example of deductive reasoning. It is the reasoning of mathematics and philosophy and is used to test the validity of general ideas in all branches of knowledge. General principles are constructed and then used as the basis for examining specific cases.

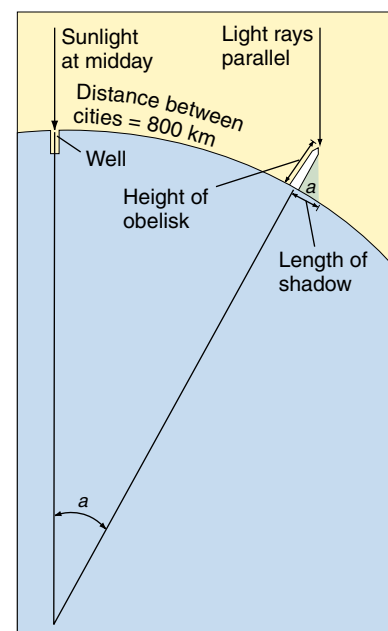
### Inductive Reasoning

Inductive reasoning uses specific observations to construct general scientific principles. *Webster's Dictionary* defines science as systematized knowledge derived from observation and experiment carried on to determine the principles underlying what is being studied. In other words, a scientist determines principles from observations, discovering general principles by careful examination of specific cases. Inductive reasoning first became important to science in the 1600s in Europe, when Francis Bacon, Isaac Newton, and others began to use the results of particular experiments to infer general principles about how the world operates. If

FIGURE 1.3

**Deductive reasoning: How Eratosthenes estimated the circumference of the earth using deductive reasoning.** 1. On a day when sunlight shone straight down a deep well at Syene in Egypt, Eratosthenes measured the length of the shadow cast by a tall obelisk in the city of Alexandria, about 800 kilometers away. 2. The shadow's length and the obelisk's height formed two sides of a triangle. Using the recently developed principles of Euclidean geometry, he calculated the angle,  $a$ , to be  $7^\circ$  and  $12'$ , exactly  $\frac{1}{50}$  of a circle ( $360^\circ$ ). 3. If angle  $a = \frac{1}{50}$  of a circle, then the distance between the obelisk (in Alexandria) and the well (in Syene) must equal  $\frac{1}{50}$  of the circumference of the earth. 4. Eratosthenes had heard that it was a 50-day camel trip from Alexandria to Syene. Assuming that a camel travels about 18.5 kilometers per day, he estimated the distance between obelisk and well as 925 kilometers (using different units of measure, of course).

5. Eratosthenes thus deduced the circumference of the earth to be  $50 \times 925 = 46,250$  kilometers. Modern measurements put the distance from the well to the obelisk at just over 800 kilometers. Employing a distance of 800 kilometers, Eratosthenes's value would have been  $50 \times 800 = 40,000$  kilometers. The actual circumference is 40,075 kilometers.



you release an apple from your hand, what happens? The apple falls to the ground. From a host of simple, specific observations like this, Newton inferred a general principle: all objects fall toward the center of the earth. What Newton did was construct a mental model of how the world works, a family of general principles consistent with what he could see and learn. Scientists do the same today. They use specific observations to build general models, and then test the models to see how well they work.

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**Science is a way of viewing the world that focuses on objective information, putting that information to work to build understanding.**

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