1.3 Scientists Study the Natural World

The idea of biology as a "rapidly changing field" may seem strange if you think of science as a collection of facts. After all, the parts of a frog are the same now as they were 50 or 100 years ago. But memorizing frog anatomy is not the same as thinking scientifically. Scientists use evidence to answer questions about the natural world. If you compare a frog to a snake, for instance, can you determine how the frog can live in water and on land, whereas the snake survives in the desert? Understanding anatomy simply gives you the vocabulary you need to ask these and other interesting questions about life.

A. The Scientific Method Has Multiple Interrelated Parts

Scientific knowledge arises from application of the **scientific method,** which is a general way of using evidence to answer questions and test ideas (figure 1.10). Although this diagram may give the impression that science is a tedious, step-by-step process, that is not at all true. Instead, science combines thinking, detective work, communicating with other scientists, learning from mistakes, and noticing connections between seemingly unrelated events. The resulting insights have taught us everything we know about the natural world.

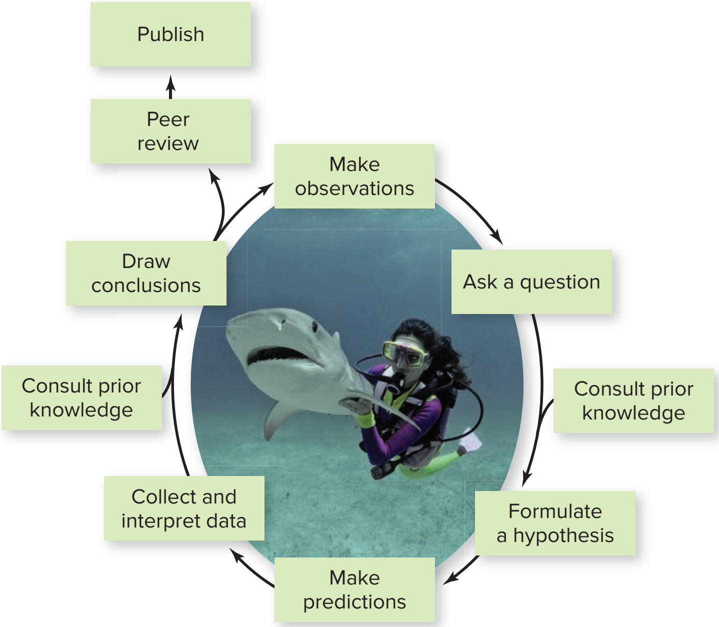

Figure 1.10 Scientific Inquiry. This researcher studies tiger sharks; her observations could lead to questions and testable hypotheses. Additional data, combined with prior findings, can help support or reject each hypothesis. Peer review determines w1hether the results are publishable.
Photo: © Jeff Rotman/Getty Images RF

Observations and Questions The scientific method begins with observations and questions. The observations may rely on what we can see, hear, touch, taste, or smell, or they may be based on existing knowledge and experimental results. Often, a great leap forward happens when one person makes connections between previously unrelated observations. Charles Darwin, for example, developed the idea of natural selection by combining his understanding of Earth's long history with his detailed observations of organisms. Another great advance occurred decades later, when biologists realized that mutations in DNA generate the variation that Darwin saw but could not explain.

Hypothesis and Prediction A **hypothesis** is a tentative explanation for one or more observations. The hypothesis is the essential "unit" of scientific inquiry. To be useful, the hypothesis must be testable—that is, there must be a way to collect data that can support or reject it. Interestingly, a hypothesis cannot be *proven* true, because future discoveries may contradict today's results. Nevertheless, a hypothesis becomes widely accepted when multiple lines of evidence support it, no credible data refute it, and plausible alternative hypotheses have been rejected.

A hypothesis is a general statement that should lead to specific **predictions.** Often, the prediction is written as an if–then statement. As a simple example, suppose you hypothesize that your lawn mower stopped working because it ran out of gas. A reasonable prediction would be "If I put fuel into the tank, then my lawn mower should start."

Data Collection Investigators draw conclusions based on data (figure 1.11). The data may come from careful observations of the natural world, an approach called discovery science. The National Audubon Society's annual Christmas Bird Count is a case in point: For more than a century, thousands of "citizen scientists" have documented the ups and downs of hundreds of bird species nationwide. Another way to gather data is to carry out an experiment to test a hypothesis under controlled conditions (section 1.3B explores experimental design in more detail).

Discovery and experimentation work hand in hand. As just one example, consider the well-known connection between cigarettes and lung cancer. In the late 1940s, scientists showed that smokers are far more likely than nonsmokers to develop cancer. Since that time, countless laboratory experiments have revealed how the chemicals in tobacco damage living cells.

Analysis and Peer Review After collecting and interpreting data, investigators decide whether the evidence supports or falsifies the hypothesis. Often, the most interesting results are those that are unexpected, because they provide new observations that force scientists to rethink their hypotheses; figure 1.10 shows this feedback loop. Science advances as new information arises and explanations continue to improve.

Once a scientist has enough evidence to support or reject a hypothesis, he or she may write a paper and submit it for publication in a scientific journal. The journal's editors send the paper to