What is the scientific process?

The scientific process is not *the* process at all. It is, rather, a general and usually cyclical process of systematic learning. Science, like all processes, is fluid, dynamic, and changing. Having said that, it is also true that science has some constants that serve as its foundation.

The foundations of science include a respect for past learning, a systematic approach to new learning, honesty, curiosity, and accuracy. Science is usually divided into two large categories known as basic science and applied science. Basic science, if it is used to address a specific problem, is approached with a longer-range view of the problem and its solution. The scientist doing basic science may study topics that appear peripheral to the problem. Often curiosity, not a problem, stimulates basic science. Even so, basic science has often led to some of the most stunning solutions.

Applied science is much more widespread and its research methods are directly related to an identifiable problem. These are problems identified by some segment of society as being important. Examples include health and disease research, technology development to improve a product, or environmental science to learn more successful ways to manage forests. The scientists in the *Natural Inquirer* are environmental scientists who are working on behalf of the American public to find ways to sustain the health and productivity of the Nation's natural resources. Their work is almost always applied science.

Within this arena of applied environmental science, there are many different disciplines. We often think of biology, geology, hydrology, climatology, and other similar sciences when we think of environmental science. However, environmental scientists can also be engaged in social science, which examines the relationship of individuals and groups to the natural environment (Examples include psychology, sociology, education, history, and economics). In the *Natural Inquirer*, one social science article is presented in almost every journal.

There is, in addition, another dichotomy within science. When scientists engage in research, they are attempting to discover new information of one kind or another. Depending on their question, the data they collect can be quantitative or qualitative. Quantitative science relies on numerical data, and qualitative science relies on non-numerical data, such as text, pictures, sound, or objects. Some of the best-known qualitative sciences are archeology and anthropology. The type of data collected and the appropriate analysis is always dictated by the question being asked or the problem to be solved.

Regardless of the label we place on a particular scientific endeavor, scientists more or less follow a general process of systematic discovery. The scientific process almost always begins with a review of what is already known about the topic or problem. This process of learning is called a literature review. Once everything possible is known about a topic or

problem by the scientist or scientific team, the research problem or question is developed. Because we will never know everything about a topic and there will always be problems to solve, scientists often have to choose between a number of problems or questions. Once a problem or question is identified, the scientist must clearly state the problem or question in a way that lends itself to systematic research.

At this point, scientists may state their research question as a hypothesis. As you read the *Natural Inquirer*, however, you will see that this is not always the case. What is the case is that every research project begins with a researchable problem or question, clearly stated in such a manner as to facilitate its investigation. Sometimes, scientists will state their expectations as predictions. Often, they will simply begin their research with a researchable problem or question.

In the *Natural Inquirer*, the literature review and research problem or question are presented in the "Introduction" section. The literature review is usually presented as background to the problem or question. Because of the succinct format of the *Natural Inquirer*, previous research is usually not cited. In a scientific paper, however, past research leading up to the problem or question is almost always cited.

Once a researchable problem or question has been stated, the scientist or scientific team must develop a systematic method for collecting data, analyzing it, and reporting findings. This is true of all of the categories of science listed above. Often, qualitative researchers will begin with a defined approach, but will remain open to modifications when conditions suggest. In environmental science, conditions may force or suggest a modification in methods. Whenever a modification is made, it is documented and presented as a part of the final research report.

During the data collection phase, scientists must be meticulous with their observations, record-keeping, and other data collection. A scientific project cannot be better than the quality of its data. Analysis follows the collection and storing of data. In the *Natural Inquirer*, the analytical processes used are often omitted because of their complexity. For most environmental sciences including those within the social sciences, mathematical equations and complex computer programs are used to analyze data. (This is not *always* the case, however.) Data analysis, regardless of its complexity, is the reduction of large amounts of data into manageable and useable information.

Once the analysis has been done, the findings are presented. In environmental science, this is done using text, graphs, charts, figures, maps, and photos. Often in a scientific paper, the results are presented without any commentary regarding their meaning. In the *Natural Inquirer*, the "Methods" section contains the data collection, analysis, and presentation of findings.

Once the findings have been presented, scientists make sense of their findings by placing them back into the context of what is already known. They attempt to answer the question, "What do these findings mean in light of what we already know about the topic, problem, or question?" In this part of the scientific process, a discussion of methodological issues and suggestions for future research may be given. While the research may have answered the original research question or helped to solve the problem, a research project almost always leads to new

questions. These questions may be tackled by other scientists, or by the same scientist or team of scientists in their next research project. In this way, science progresses in a cyclical process. In the *Natural Inquirer*, this part of the research process is presented in the "Implications" section.

When scientists communicate with other scientists, they usually report their research in peer-reviewed journals. These journals are usually published by an independent professional organization or an independent publisher. A peer-reviewed journal contains papers that have been anonymously reviewed by other scientists. In this process, neither the reviewer nor the scientist should know the identity of the other. Reviewers make comments regarding weaknesses, strengths, and suggested improvements to the paper, and ultimately the reviewer has a vote as to whether a paper is accepted or rejected for publication. In this way, scientific quality and credibility is maintained.

There are other methods used by scientists to share and report their research. Within the Forest Service for example, scientists prepare papers called General Technical Reports. These papers are peer-reviewed but are published by the Forest Service as individual reports. Other methods of presentation include conferences and Web-based publications. Scientists may also publish their results in books. Within the scientific community, more credibility is placed on research that has undergone a peer-review at some point. In the *Natural Inquirer*, most of the articles presented are based on peer-reviewed research. You can check the source of each *Natural Inquirer* article by examining the citation given at the end of the article.

In summary, the scientific process is not a rigid set of steps but is more of a systematic and critically reflective way of learning, documenting that learning, and then sharing it. Everyone is a scientist when they employ the scientific process, even for simple problem solving tasks. When your students learn how to employ the scientific process, they can become better problem solvers in their own lives.