Student Reading # 5

The Goals of Science

> *Man masters nature not by force but by understanding. This is why science has succeeded where magic failed: because it has looked for no spell to cast over nature.*
>
> —Jacob Bronowski

If you are fortunate, your school science experiences have included opportunities to design and conduct inquiries. *Inquiry* means literally "to look into." It is a crucial part of science along with exploration, discovery, experimentation, and research. Each of these terms means something different. In this reading, we will explore why do scientists do what they do. What are the goals of science?

If you've been taught that the goal of science is to explore and discover, you have part, but not all, of the answer. Scientists do explore and discover some of the time, but that is not all there is to science. Christopher Columbus, Vasco da Gama, Cortes, and Marco Polo were all explorers but they are not usually thought of as scientists. On the other hand, NASA's Mars Rover and Voyager programs and similar programs of the European Space Agency are considered science. What is the difference? It's not just the technology.

The difference is that scientists discover and explore to construct *descriptive and explanatory models* for their own sakes. These models, in their final form, appear as *research reports*. Contrary to what you may have been taught, science is not focused on invention, or finding solutions to solving practical problems. Those goals belong to technology, which is the subject of another paper. Trust me for now.

Okay. So what is my basis for claiming that the goal of scientists is to build models?

From the earlier papers in this series, you know that all meaningful knowledge exists as mental models. Whenever you learn something new, you must construct a mental model of it. This model is built by the processes within our brains using both the information we take in through our senses and from our existing mental models—memories.

We cannot meaningfully understand any of our experiences without referring to our existing mental models. Once we have constructed our mental model, then we can use it as a template to build an *expressed model* in whatever medium we are using: in words on our computer; on paper; in a verbal report; or in some other medium such as wood, clay, plastic, and so on.

This is true no matter what we are studying. Historians create models of the past; sociologists create models of social structures; artists create models to portray objects, ideas, and emotions. Scientists construct factual models to describe

and explain physical reality. They do not have to have any purpose beyond that. Good scientists love to build good models, just as artists love to create in whatever medium they work in. Philosophers also create models of reality, but do not always restrict their efforts to factual models. Science originated as a form of *natural philosophy* that created and accepted only those explanatory models that could be tested and verified by facts.

Scientists, of course, do not have any outside authorities, like your teachers, to tell them whether their models are right or wrong. They rely instead on others in the *scientific community* to review their models and either accept or reject their models. While anyone may read and comment upon these models, other scientists with specific expertise in the subject being studied will carry the most weight in determining whether a given model is scientifically valid. These experts will examine the model to see whether the methods are sound, and whether the claims made in the model follow logically from the data.

Scientists usually build a model with some idea of where they want to end up; that is, they know the model they want to build before they start. Scientists do explore and they do discover, but once a discovery is made, they have to construct a meaningful model of it to present to others. Scientists don't tinker around in their labs until they happen upon a discovery. Discoveries that happen by chance (a process called *serendipity*) are by definition lucky accidents.

Very few scientists make discoveries that lead science in startlingly new directions. Most of them engage in what we might call *routine science*, focusing on the gaps and holes in the existing theoretical (explanatory) models to fill them. On rare occasions, their efforts lead to some sudden finding, insight, or understanding that an existing explanatory model cannot account for. They then must substantially modify the model or create a new model to explain the new facts. But the focus is on creating the model. The discovery comes before that.

Pulsars are rotating stars that emit beams of radiation in a pulsing manner, like celestial lighthouses. When the first one was detected in 1967, the scientific models then in place could not explain the extremely regular pulsations. Some scientists (and many proponents of extraterrestrial life) speculated that the signals might be coming from an alien civilization. Over the years that followed, though, scientists created a simpler new explanatory model that eliminated the need for alien civilizations to explain the phenomenon—a disappointment to searchers for extraterrestrial life.

Scientists build models through research and experimentation—two different but related activities. Not all research is experimental. *Research*, as the root of the word implies, is a systematic search. You may have done library research in English to find out about a particular topic. Research is more directed than exploration, in that it is focused on a particular goal.

Experiments include an element of deliberate testing; scientists conduct them to test their models. The test often involves a *prediction*: if my explanatory model is correct, then action X will lead to outcome Y. Experiments are a particular class of research, but not all research includes experimentation.

The ultimate goal of all science is the production of factual, research-based models of physical phenomena that withstand critical examination by scientific experts. Their research reports are expressed models including their actions and findings. It's not enough just to discover a thing: You also have to describe or explain it accurately. You have to create an argument for it. We'll talk more about that in another paper.

For Discussion

1. Does the explanation of science in this paper clarify the role of scientists for you? If not, what is confusing?
2. How are a scientist's expressed models different from those of a novelist? What is each trying to achieve? What assumptions do they make?
3. A scientist is studying the reactions of wolf spiders to sudden loud sounds. Follow the model-building process as the scientist completes her project.