Framing the Discussion: What To Tell Students About Science

by Joyce Lucas-Clark

When I began teaching college geology and paleontology, I anticipated some resistance from those who believed in a 6000 year-old earth, from creationists and those who advocate intelligent design, or possibly from students who simply wished to be consistent with the family religion and still take a course involving evolution and the Big Bang. Sure enough, I did find such resistance, and I found it could take up valuable class time trying to justify science and scientific endeavor. So I have started out each class, each semester, with a forthright declaration about the basic principles of science: what it is and what it isn't. I find that this initial discussion (and I do turn it into a discussion) pretty well puts to rest any further digressions. Here is the basic declaration.

The term "science" comes from the Latin verb "scire" meaning to know. Both in Latin and English, science does not refer to all kinds of knowledge, nor of every way in which one may "know." Science refers to knowledge that can be demonstrated, objectively, in the concrete, factual realm of reality. Matters that are inherently outside of objective reality, those things that are subjective or internal and cannot be demonstrated objectively, are outside of the realm of natural science.

Science is distinct from the humanities and the arts, which also deal with facts and the concrete but in the context of values and aesthetics. A piece of art or literature communicates largely through an appeal to human emotions and sense of beauty or importance. This is not to say that the truth so communicated is not valid; it is simply not the subject or method of science.

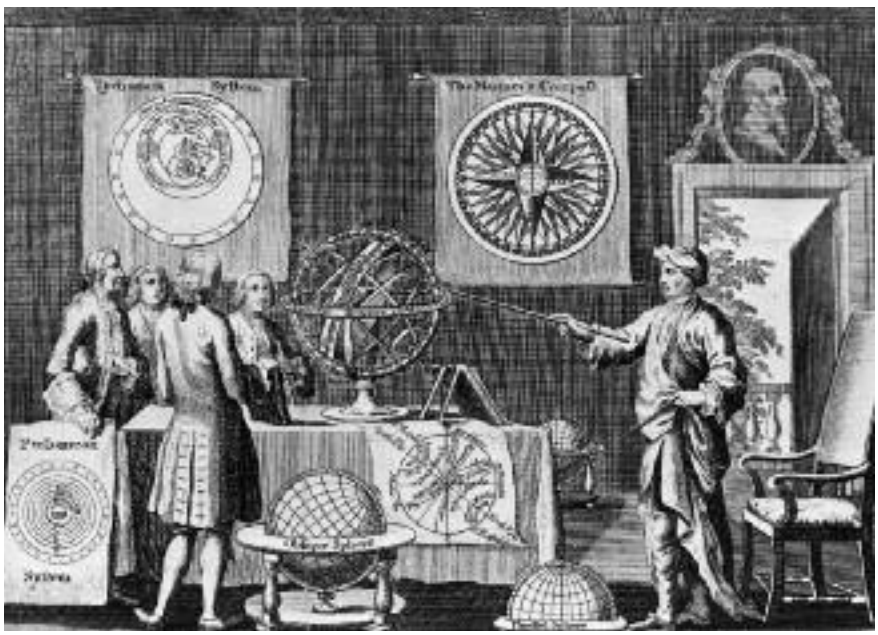
Science is distinct from human law, which also deals with facts, but for the purpose of establishing justice, right and wrong, ethics. Scientists, being human, often find themselves dealing with ethical questions in their work,

but ethics is not the subject of their work. Science itself is amoral. It exists purely to know what is.

Science is distinct from theology and religion because it does not deal with the spiritual and the supernatural. The spiritual is not demonstrable, objectively, and the supernatural is by definition outside of the natural or objective reality. Furthermore, one can explain all things by invoking the supernatural, whereas science can never explain all things. Science is inherently uncertain, while theology is certain.

Scientific inquiry is characterized by objectivity. A scientist, ideally, does not become attached to a certain hypothesis and seek to prove it. Rather, he or she adopts multiple working hypotheses and seeks to eliminate them. Scientists also accept that there will always remain a degree of uncertainty in their conclusions. It is the hallmark of a good scientific principle or theory that one can state clearly how it could be disproved. "Science is about inquiry and discovery, unearthing the unanticipated, spotting surprising relationships in complex systems, confronting and coping with divergent streams of evidence, looking at data skeptically and allowing knowledge to accumulate over time."[1]

Authority is not a criterion for science. Because a person is labeled a scientist or has credentials to verify his education or expertise in science does not mean that all of his work is science, or should be taken without skepticism. Whether a scientist's work is widely accepted or rejected is not necessarily a reflection of its worth. Galileo's work was soundly rejected in his time; more recently Wegener's concept of continental drift was



overwhelmingly rejected then just as overwhelmingly accepted within less than a century.

A scientific principle—also called a natural law—is a generalization arrived at by scientific methods of fact gathering and experimentation, usually by inductive reasoning. The principle can be used deductively to describe or predict individual cases or to derive other principles. Examples of scientific principles include Newton's laws of physics and, in geology, the principle of uniformitarianism and the principle of original horizontality. A scientific principle is similar to an axiom in plane geometry.

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A scientific theory is a hypothesis or set of hypotheses that have been substantiated by evidence. A theory is usually more involved and complicated than a principle, with many more areas of doubt and refinement possible. A scientific theory is more similar to a theorem and proof in plane geometry.

As I mentioned, taking a few moments to discuss the ideas behind science at the beginning of each semester clarifies the framework for the course. Knowing what science is and isn't allows all students to start from a similar understanding and helps avoid unnecessary tangents.

ENDNOTES

1. Atkinson and Feurer, *San Jose Mercury News,* July 23, 2006.

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