A NOTE FROM THE EDITOR: SCIENTIFIC THOUGHT

Most professions seem to encourage certain approaches to the way their members think. This goes for brick layers as well as lawyers. One thing is for certain; scientists have a certain way of thinking. The challenge, even for scientists, is in identifying just what it is that sets us apart in our ways of thinking. The subject, on which numerous volumes have been written, is still quite unresolved. The first person I came across in my studies that seriously addressed this issue of scientific thinking or reasoning was a contemporary of Galileo, Francis Bacon. His aphorisms in the *Novum Organum* address many of the most difficult challenges in how we should go about thinking … as scientists. One of my favorites can be summed up as: if science wants to advance, it must be willing to ignore what it assumes to be true. Being probably the first to fully attack the subject during a time when many "scientists" were as likely to practice astrology as astronomy, Bacon had his work cut out for him.

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Surely, one of the trademarks of scientific thought is in the very word science derived from *scientia* (Latin … knowledge) or *scire* (Latin … to know). Notice the word does not mean "believe" (Latin … *credo*). In the interest of setting our terms, which is a habitual concern of scientists, there is more than a fine difference between knowledge and belief. Knowledge is what we hold in our minds if it is true to the nature of the world, whereas belief need only be a resident of our minds with little natural fidelity. One of the marks of knowledge is how we cherish and preserve it, in stories, books and art. It is this drive to collect and preserve knowledge that in large part makes us human. In some respects then, science wishes to take humanity to another level through knowledge. There are different ways of knowing something. Science proposes to know nature a certain *way* and not necessarily at the exclusion of other *ways* such as religion or art.

Scientists choose to know the nature of the universe by observation and experimentation. When we feel we are far enough along, we form a theory which will typically have some value in its ability to predict nature. Some people[1] have been clever enough to point out that one test of whether a prediction is scientific is that it must be risky and specific. Attaching a prediction to something as dependable as the sun rising and setting is hardly risky, while vagueness can ascribe to predictions arising from knowledge for what belongs to chance. In the event that a theory is accurate and withstands years of testing in its predictions, it is often called a law. Some other clever people[2] point out that any scientific theory cannot actually be "proved" true and "falsifiability" is a signpost of scientific thought and a requisite for its theories. A particular theory, especially an appealing theory, is subject to constant verification through a variety of approaches. This could be called "proof by induction", where enough cases have shown the theory holds true. During the constant process of verification the theory is vulnerable to disproof from a single well documented study. The point being that no amount of data and no number of studies can conclusively show the validity of a theory, while a single instance can conclusively reveal a theory as invalid. As scientists proceed through this process they look for causal (not casual) relationships and are keenly aware that correlation is not necessarily causation. Most theories cannot stand the onslaught and die quickly and/or quietly. Other theories that have held their ground for decades, as in Newton's laws of motion, when found to be invalid, are invalid under circumstances that allow the basic theory to survive in a matured form.

There are central paradigms that scientists hold as immutable … syllogistic reasoning for one. There are probably no "facts" of science that hold the same stature. Curiously, the greatest scientific thinkers have often been those willing to reject some of the most central of "facts". Based on Kepler's rejection of the circular motion of the planets,

Newton held Kepler in the highest regard. As a matter of human nature, people (scientists included) are not always kind to those who dare to think differently. This is understandable, even today. As a biologist, it is more than unsettling to watch some "facts" fall to the scientific method…all enzymes are no longer proteins, genes jump around in the genome, and a simple misfolded protein can be an infectious agent. These advances struck at some roundly accepted "facts" in biological science. Accepting these changes made for added complexity in the already overwhelmingly complex world of living systems. These thinkers did something somewhat distinctive to thinkers in and of science. They were willing to do as Bacon advised: ignore what science accepts to be true. Of interest here is that, in most every case I can think of where science advanced upon the rejection of an accepted "fact" the fact was, in fact, assumed from what seemed to be logical and obvious. Newton never said his laws applied to all frames of reference regardless of speed, and although we biologists became accustomed to the notion that all infectious agents are organisms and all enzymes were proteins, no experimental evidence excluded the other eventualities. We should have learned our lesson from viruses, which are NOT organisms.

One of the most confusing things to non-scientists is that scientists are seldom willing to completely trust their own facts, and seldom are scientists willing to accept something as beyond reproach. Probably the most defining characteristic of novel scientific thinking is the willingness to reject or ignore what seems obvious and factual and find a new way. Physics went through this reformation after quantum theory took hold and ushered in what is often called the "new physics". No doubt other sciences will experience the same when thinkers of great thoughts find a new way to know nature.

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Editor-In-Chief

1) Karl Popper
2) Bertrand Russell, Karl Popper