

## DOES SCIENCE NEVER ABSOLUTELY PROVE ANYTHING?

It is with a great deal of reluctance that we are responding to a Letter to the Editor of *Science*. We were hoping that someone else would address the letter by Gleick et al (2010) that was signed by about 250 members of the (US) National Academy of Sciences. That letter includes the statement “All citizens should understand some basic scientific facts. There is always some uncertainty associated with scientific conclusions; science never absolutely proves anything.” Unfortunately, we must disagree.

We are also confused by the statement included in the letter that concedes the existence of scientific “facts.” Obviously whereas the authors agree that there are facts, they do not agree that science can prove anything. The letter includes the statement: “...when some conclusions have been thoroughly and deeply tested, questioned, and examined, they gain the status of ‘well-established theories’ and are often spoken of as ‘facts.’”

Let us use some examples of “absolutely” proven science:

1. There is no reason to doubt the laws of physics governing acceleration and momentum. These laws are the basis for a large number of industrial operations, transportation and numerous other activities.
2. Constituents of an atom include protons, neutrons (except for  $^1\text{H}$ ) and electrons. Nuclear power, nuclear medicine and numerous other industries are based on this proven structure.
3. There is no question that moon rotates around the earth and earth around the sun.
4. The elemental composition of a large number of chemical compounds is known and is the basis for the chemical, pharmaceutical, and numerous other industries.
5. The gross anatomy of humans is well-established and beyond dispute. Normal humans have two hands, two feet, two eyes, two ears, and one nose. They also have brains, lungs, kidneys, livers, and stomachs.
6. Under standard conditions water freezes at  $0\text{ }^{\circ}\text{C}$  and evaporates at  $100\text{ }^{\circ}\text{C}$
7. Human genetic material is composed of DNA which includes two complementary strands and undergoes transcription and translation.
8. The reaction of silver nitrate and sodium chloride at sufficient concentrations produces a precipitate consisting of silver chloride.
9. Whereas certain diseases are caused by viruses, some others are caused by bacteria.

It would be fruitless to describe other examples. Virtually every high-school student can identify many other examples.

What happened? We are familiar with the scientific accomplishments of several signatories of the letter and have difficulties understanding why such a large number of exceptionally distinguished and accomplished individuals would sign a letter containing

such a fundamental error. Our only explanation is that the urge to perform what they considered to be a noble cause was responsible for overlooking the error.

The conventional evolution of scientific knowledge often starts with a hypothesis whose merit has to be evaluated by experiments and other tools. Often a theory is the next step after adding scientific evidence to a hypothesis. A theory can also be the start of the process if sufficient evidence is provided in its formulation. The final goal in scientific endeavor is the formulation of a scientific law. Whereas theories include assumptions and unproven ideas, laws contain neither. These ideas were further expanded in our book. The second edition of our book *Best Available Science: Metrics for Evaluation of Scientific Claims* (Moghissi et al. 2010) is based on four principles (open-mindedness, skepticism, universal scientific principles and reproducibility) and three pillars (reliability and classification of scientific information and areas outside the purview of science). The classification of scientific information includes proven, evolving and borderline science. It also includes a description of fallacious information.

Global Climate Change (GCC) is extremely complex. Recognizing the need to attend to this subject, as the Editor of *Environment International*, one of us (AAM) started the preparation of a topical issue devoted to two pioneers of GCC; Willard F. Libby and Hans Süß, and the issue was published in 1979 (Libby 1979). Similarly, in 1989, one of us (AAM) chaired an international panel of more than 50 distinguished individuals for the American Society of Mechanical Engineers (ASME 1989) devoted to energy and environment that addressed GCC, and produced a statement that was adopted by the American Association of Engineering Societies. These activities attempted to assist decision makers to take appropriate actions.

The scientific foundation of GCC includes proven, evolving and borderline science. Unfortunately, as currently practiced and expressed by Gleick et al., it also includes areas outside the purview of science notably Societal Goals. The task of the scientists is to provide information pertaining to the reliability, the status of science, the missing information, and other scientific aspect for each segment of scientific information. The scientific community would be well advised to follow the advice of William Ruckelshaus (1983) who stated that “In fact, all scientists should make it clear when they are speaking as scientists – *ex cathedra* – and when they are recommending policy they believe should flow from scientific information.” He further emphasized: “What we need to hear more from scientist is science.” Ruckelshaus was legally forced to make major decisions, using incomplete or inadequate scientific information. We are facing a similar situation with GCC.

We have observed with a great deal of concern the current GCC discussions. Those involved with the scientific aspects of GCC would be well advised to try classifying various segments of the GCC science into the proven, evolving, and borderline science. In particular, they should be urged to avoid getting involved in societal conclusions that are derived from science, thus violating the Ruckelshaus Effect. We suggest that such an approach would result in disappearance of a much of disagreements.

Those of us, who have devoted our professional life to science and environmental protection, are extremely concerned. The current approach is not serving the interest of

science and is detrimental to the cause of environmental protection. The authors of the letter should recognize that based on the BAS/MESC:

“A scientific claim is settled if and when any investigator who has the necessary skills, and, depending upon the issue, requisite equipment and facilities, is able to reproduce and confirm it.”

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*Note: An abbreviated version of this document was submitted as a Letter to the Editor to Science. As the Journal chose not to publish it, the original version is provided to the public.*

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