The Role of Academies of Science in the Critical Examination of New Ideas: Looking at Gaia

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Abstract

In science, new ideas have to fight for acceptance. The process is essential to ensure the founded confidence of the scientific community. There is a continuum ranging from speculation at one end through theory to fact at the other end. This paper deals with the role of Academies of Science in encouraging the widest possible discussion of legitimate theories. The Gaia Theory of the earth as a self-regulating system is used as an example of the type of controversial theory that benefits from scientific discussion. A description of the Gaia Conference follows the paper.

"A scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die and a new generation grows up that is familiar with it."
-Max Planck

Facts, Theories, and Speculation

In science a new idea has to fight its way to acceptance. The path may be long and conflicted. The opposition may be intense and tortuous. The process, however, is necessary to ensure the emergence of a founded confidence on the part of the broad scientific community.

Perhaps one of the most famous examples of the opposition a new theory can meet comes in the case of Alfred Wegener and his concept of what we now call continental drift and plate tectonics. Wegener started presenting his theory in 1912. The scientific community reacted with ridicule and derision. His personal treatment by colleagues was almost brutal. His work, however, is now considered by many the most important element of progress in the Earth sciences of the 20th century. Nonetheless, Wegener was never able to obtain a university position in his native Germany.

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Wegener's major problem was that he could propose no mechanism for continental drift. And so, this theory was subjected to intense criticism. Perhaps also there was a feeling that he was out of his field. After all, his doctorate was in astronomy, not geophysics or anything related.

Science, however, cannot afford to let ideas sweep through a field the way social fads do in modern society. Consider the case of Trofim Lysenko, a Russian biologist who became the darling of Joseph Stalin. In a famous speech in 1929 Stalin extolled practical scientists against the more theoretical ones who joyfully spent their days studying fruit flies while a famine raged all around them.

Lysenko was a former country boy who could inspire peasant farmers who had been largely turned off by Stalin's collectivization projects. Lysenko did not believe in careful bench work in agriculture. His ideas were a mixture of Lamarkianism[1] and other half examined notions. There was no control from the profession. In fact, he waged a bitter and savage campaign against established scientists with the happy support of the NKVD, the then Soviet secret police. It took some time after the death of Stalin for Soviet science to break free from Lysenkoism. Science requires a self-discipline to remain out of the clutches of charlatans and ideologues. New ideas cannot and should not expect to win easy victories.

THE ROLE OF ACADEMIES OF SCIENCE

Academies of science have a special role in the exposition and critical examination of new ideas. They provide a willing but intelligent audience to which an innovator can make a presentation. In so doing, academies do not endorse such theories. They only allow them to be easily and widely exhibited and so begin their battle to achieve confirmation and acceptance or relegation to the dustbins of history.

Of course, academies of science start with an established concept of what science is. Academies are not in the business of providing platforms for mountebanks and crack-pots. There exists, therefore, a filter that academies use to select concepts worthy of consideration.

WHAT IS A THEORY?

To begin with, there exist certain known facts. Cooling water under normal conditions will result in its freezing. Under normal conditions, a cubic foot of lead is more massive than a cubic foot of hydrogen. In the healthy human body, blood circulates through the structure. There is a body of statements not dependent on opinion.

At the other extreme there are statements that are of the order of guesses, speculations, initial conjectures not yet subjected to verification. A theory may start in such an environment. Unfortunately, many people unacquainted with science take the word "theory" to mean such untested conjectures.

But for scientists a theory must link together facts, show their interrelationships, and present some kind of a model that makes the situation intelligible. Even more, it must at some point exhibit verifications so that the theory can be confirmed or rejected. Only then does an idea move to the status of being a theory.

Every field of developed science has such fundamental structures that have been hammered out over time and through repeated critical evaluation. Wegener's plate tectonics, Mendel's genetics, Newton's explanation of the tides, Darwin's evolution, big bang cosmology, and more. All are subject to analysis and revision as new data become available or new understandings emerge.

A classical example is the Michelson-Morley experiment. In Michelson's day, Maxwell's laws of the electromagnetic field were a prized possession. Maxwell, however, used a concept of the ether to hold his ideas together. Michelson decided to measure the motion of the earth through that strange entity. His experiment was brilliantly conceived and meticulously carried out. After all, Michelson was one of the greatest experimentalists the human race has ever produced. But the result was a null value. Ether could not be shown to exist.

It is not totally clear whether this experiment was the motivation of the re-thinking Einstein then produced in his 1905 Theory of Special Relativity. But it could have been. To this day it is easy to explain the Theory of Relativity by starting from the Michelson-Morley experiment. Einstein himself seems to have been thinking in a different direction in his original work in the field. The point, however, is that the Michelson-Morley experiment and the Theory of Special Relativity exhibited a reformulation of Newton's rich concepts of space and time. New data and new insights can refashion even seemingly established theories.

Constant and consistent verifications of Special Relativity have made it an accepted part of our model of reality, and part, we think, of the laws of the universe.

Of course, Einstein went on to develop his ideas further and came to include acceleration and gravity in his perspective and so produced the General Theory of Relativity. Continuing and ever more accurate measurements are part of the life of this theory and its steady evolution.

It is worth recalling, however, that Einstein's work did not immediately win acceptance. It had to fight to earn its place. Einstein did not receive his Nobel Prize in Physics for relativity. It was still too controversial in 1921. He received the prize for his work on the photoelectric effect which won more ready acceptance although it, too, had to be verified by sets of experiments.

Perhaps the great editor who published Einstein's 1905 articles had the best statement. That was Max Planck who had himself achieved fame by his work originating modern quantum mechanics in 1900. We have used his statement at the head of this article.

THE GAIA THEORY

The point of this discussion is to treat a theory that is controversial and even hotly disputed. How does an academy of science act in such a case?

The example is James Lovelock's approach to understanding life and evolution – the Gaia theory.

Lovelock began speculating about the possibility of the Earth's being a self-regulating system in 1965 when he was part of NASA's planetary exploration team. He began to formulate a hypothesis, namely that living organisms regulate the atmosphere in their own interest.[2] He discussed this hypothesis with the author, William Golding (*Lord of the Flies*), a discussion that resulted in Lovelock's accepting Golding's suggestion that he name his fledgling hypothesis "Gaia" – a result that has dogged the theory since its inception. Scientists find it very difficult to take seriously a theory named after a Greek Earth Goddess.

Over time, the hypothesis lost its teleological aspect and the Gaia Theory as now set forth by Dr. Lovelock and his close collaborator, Dr. Lynn Margulis, proposes that the Earth is a self-regulating system made up of physical, chemical, biological, and human components.[3] As with all but the most simple mechanical systems, sophisticated feedback loops are at work. Despite Lovelock's insistence that he never meant to imply that the earth was a living, purposeful organism, that he used the term "living" only in a metaphorical sense, many fringe scientists adopted what is now known as the "strong" Gaia theory – *i.e.*, the Earth is alive in the biological sense. This silliness has become the strawman that is often used to discredit the theory.[4]

The more mainstream Gaia has made a number of striking predictions. Among them are: that Mars would be lifeless (based on atmospheric evidence and confirmed by the Viking mission in 1977); that elements are transferred from the ocean to the land by biogenic gases (supported by the discovery of dimethyl sulphide, dimethyl selenide, and methyl iodide in 1973 and 2000); that climate is regulated through biologically enhanced rock weathering (strengthened by the discovery that microorganisms greatly increase the rate of rock weathering.[5])

Did all that convince the scientific world that Gaia was a true representation of reality? Not entirely. Controversy still abounds, with many scientists pointing out that theories other than Gaia could have made the same predictions.

In addition, Stephen Schneider observed that "Controversy occurred for at least three reasons: (1) there was outright hostility to the name 'Gaia'…; (2) there was little or no shared understanding…of the 'Gaia hypothesis;' and (3) studying Gaia required strong multidisciplinary training and an interdisciplinary commitment that transcended traditional scientific approaches."[6]

Despite the scientific uneasiness with Gaia, the first American Geophysical Union Chapman Conference on Gaia was held in 1988 to discuss the possibility of active climatic regulation systems and the relative importance of feedback processes between organic and inorganic compounds. This Conference was a major factor in stimulating interdisciplinary work as well as introducing Gaia to the mainstream of scientific debate. Many of the results of that debate were explicated in the second AGU conference held in 2000. The papers given there were collected in *Scientists debate Gaia*.[7] A partial listing of the contents of that volume illustrates Gaia's success in fostering the interdisciplinary research that was so formidably resisted less than two decades ago:

Lynn Margulis, "Clarifying Gaia: regulation with or without natural selection";
Timothy M. Lenton, "Gaia is life in a wasteworld of byproducts";
Tyler Volk, "Models and geophysiological hypotheses";
J. Scott Turner, "Homeostatic Gaia: an ecologist's perspective on the possibility of regulation";
David Wilkinson, "Phosphorus, a servant faithful to Gaia? Biosphere remediation rather than regulation;
Karl B. Foÿllmi [*et al.*] "Self-regulation of ocean composition by the biosphere";
Lee R. Kump, "A new biogeochemical earth system model for the Phanerozoic Eon";
Noam M. Bergman, Timothy M. Lenton and Andrew J. Watson – Gaia and glaciation: Lipalian (Vendian) environmental crisis;
Mark A.S. McMenamin, "Does life drive disequilibrium in the biosphere?";
K.M. Nordstrom, V.K. Gupta and T.N. Chase, "Food web complexity enhances ecological and climatic stability in a Gaian ecosystem model; and
Keith Downing, "On causality and ice age deglaciations".

A description of the next Gaia Conference, to be held in October 2006, follows the endnotes of this paper.

Whether one accepts Gaia or not, it is difficult not to admit that (1) without those conferences the interdisciplinary work necessary to the Earth sciences would not have occurred in this timeframe and (2) the on-going debate has fostered greatly increased understanding of how life and our planet work. For these reasons, the Washington Academy of Sciences is pleased to co-sponsor the Conference scheduled for October of this year (see http://www.gaiatheory.org).

To repeat our earlier statement:

Academies of science have a special role in the exposition and critical examination of new ideas. They provide a willing but intelligent audience where an innovator can make a presentation. In so doing, academies do not endorse such theories. They only allow them to be easily and widely exhibited. They can then begin their battle to achieve confirmation and acceptance or relegation to the annals of history.

End Notes

[1] A theory of biological evolution holding that species evolve by the inheritance of traits acquired or modified through the use or disuse of body parts.

[2] Lovelock, James "The Living Earth", *Nature*, **426**, pp. 769-770, Dec, 2003.

[3] This statement is virtually identical with the first bullet point of the Amsterdam Declaration, issued by a joint meeting of the International Geosphere Biosphere Programme, the International Human Dimensions Programme on Global Environental Change, the World Climate Research Programme, and the International Biodiversity Programme on July 13, 2001. It was that Declaration that helped to elevate Gaia from the status of hypothesis to that of a generally accepted theory (although not necessarily by the name of "Gaia").

[4]James Lovelock, "Reflections on Gaia", *Scientists debate Gaia: the next century* edited by Stephen H. Schneider, Cambridge, Mass. MIT Press, 2004, p. 2.

[5] op cit. "The Living Earth."

[6] Preface to *Scientists debate Gaia,* op. cit.

[7] *Scientists debate Gaia,* op. cit.